00718

Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN

JOURNAL OF SCIENCE.

EDITORS

JAMES D. AND EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS JOSIAH P. COOKE, GEORGE L. GOODALE AND JOHN TROWBRIDGE, OF CAMBRIDGE.

PROFESSORS H. A. NEWTON AND A. E. VERRILL, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA.

THIRD SERIES.

VOL. XLVI.—[WHOLE NUMBER, CXLVI.]

No. 271.—JULY, 1893.

NEW HAVEN, CONN.: J. D. & E. S. DANA.

1893.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

MINERALS, NEW ARRIVALS.

Cumengite, a new and well crystallized species associated with Boleite, just described by Prof. Mallard, from $1.50 to $5.00. This is one of the rarest of all the new species and beautiful though small.

Bouglisite, 25c. to 50c.

Boleite from 10c. to $5.00 per crystal. Groups, $1.00 to $10.00.

Selenite Crystals from Utah. Those previously advertised are sold, but a new lot is offered at lower rates. Some of these are smaller and better suited for private collections. As the locality is exhausted, prices cannot be lower. One foot to 18 inches, very good, $2.00 to $5.00; 18 inches to 3 feet, $5.00 to $25.00.

MINERAL CATALOGUE

Of 128 pages, illustrated, free to all customers, or those ordering it on headed paper; to others, 5c. Heavy paper, 10c.; bound in one-half cloth and boards, 15c.; cloth, 20c.; one-half morocco, 50c.

It is hoped that the pressure of work will soon be relieved enough to permit the issuance of the lists of many things collected and received during the past year.

BOOKS, NEW ARRIVALS.

I have recently purchased a large number of books from the libraries of I. C. Martindale, the well known botanist; G. W. Carpenter, for many years treasurer of the Academy of Natural Sciences of Philadelphia, and others. They include such rare books as the following.

Carson. Medical Botany. 2 vols, 60 pp., 100 col. plates	$ 22.50
Cooke. British Fungi. 2 vols., 981 pp., 7 plates, 1871	15.00
Lowe. Ferns. 8 vols., 1397 pp., 479 col. plates, illus., 1867	20.00
Berkeley. Cryptogamic Botany. 614 pp., 127 illus., 1857	3.50
Candolle, de. Phanerogamæ. 7 vols., illus., 1878	12.50
Corda, A. J. Flora Protogaea. 67 plates, German, 1867	7.50
Good. Family Flora. 2 vols., 752 pp., 100 plates, 1854	5.00
Gmelin. Flora Badensis, Alsatica, etc. 4 vols.	5.00
Hawes. Mineralogy, etc., of New Hampshire; illus., 1878	10.00
Knowles & Westcott. Floral Cabinet and Magazine of Exotic Botany. 3 vols., 486 pp., 154 col. plates	5.00
Linnaeus, C. Amoenitates. 9 vols., many plates	3.00
Linnaeus, C. Botanicorum Principis. 7 vols., 1785–7	3.00
Linnaeus, C. Species Plantarum. 10 vols., 1797	5.00
Acad. Nat. Sciences of Philadelphia. Proceedings of. 37 vols., to 1892. Publ., $213.00	130.00
Acad. Nat. Sciences of Philadelphia. Journal. Vols. 1–9, Part 2 inclusive. Publ., $106.00	75.00
Priestly, J. Experiments, etc., on Air. 4 vols., 1887 pp. 1775–79	10.00
Pursh. Florae Americae Septentr. 2 vols., illus. 1814	10.00
Sternberg, K. Flora der Vorwelt. 64 plates, '25. German	15.00
Tavernier. Six Voyages of. 600 pp., illus., 1678	6.00
Torrey & Gray. Flora of North America. 2 vols., 1838–40	7.50
Unger, F. Chloris Protogaea. 50 plates, '47. German	12.50
Vogel. Niger Flora. illus., 1849	5.00
Westwood. Modern Classification of Insects. 2 vols., illus., '39	15.00
Wilkes' Expedition. Some of his 4to Reports. See ad. in Previous Nos. of this Journal.	
Withering, W. British Plants. 4 vols., illus., 1830	5.00

Catalogues of books sent free on any subject, but in requesting, the subject should be mentioned. For 5c. the catalogues will be sent on heavy paper except the Medical catalogues, 225 pages, for which 10c. is asked, on heavy paper.

Dr. A. E. FOOTE,

1224-26-28 North Forty-first Street, Philadelphia, Pa., U. S. A.

THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. I.—*Studies of the phenomena of Simultaneous Contrast-Color; and on a Photometer for measuring the intensities of Lights of different Colors;* by ALFRED M. MAYER.

IT is often desirable in the study of simultaneous contrast-colors to have large surfaces colored by contrast, so that we can the better match the colors of these surfaces with rotating colored disks and thus arrive at quantitative statements of their hues. This is especially desirable in ascertaining the hues of the light of flames, of the Welsbach incandescent lamp and of the arc electric light when compared with day light, or, when compared one with another. The result of many experiments is the apparatus described in the following section and which is useful for this purpose.

Screen for ascertaining the hues of lights and the contrast-colors of these lights.—A ring is formed of white card-board by cutting out a central opening of 12^{cms} in diameter in a disk of 22^{cms} in diameter. This ring has a breadth of 5^{cms}. Another ring is made similar to this one, except that it has four narrow radial arms to support a disk of thin translucent *white* paper,* 35^{cms} in diameter. This paper disk is placed between the rings, which are then fastened together and screwed to a thin rod, on a stand, as shown in fig. 1.

*Trials with many kinds of paper showed that a white linen tracing-paper was the best. It is not possible to describe this so that one may be sure of selecting a similar paper. It was obtained of Keuffel and Esser, Fulton St., N. Y., and sold as "No. 202 Alba tracing paper."

Place the screen, thus formed, in front of a petroleum lamp and exclude the daylight from the side thus illuminated. The other side of the screen is illuminated by the light of the sky admitted through a distant window. The cardboard ring is thus illuminated on one side only by the lamp; on the other side, only by the daylight. The translucent paper transmits the lamplight to the side facing the window, while it transmits the daylight to the side facing the lamp. On the side of the screen facing the window the cardboard ring appears cyan-blue while on the side facing the lamp the ring appears orange yellow.

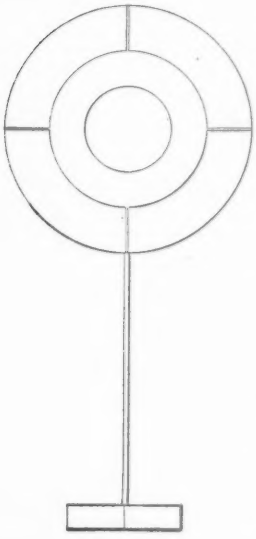


Fig. 1

Hues of the sides of the ring.—An idea of the hues and intensities of these colors, which cause astonishment even in those who are experimenters in chromatics, will be given by the description of the following experiments.

By means of a Bunsen-photometer disk I adjusted the distance of the lamp from the screen so that I obtained, as nearly as I could judge, equal illumination of the sides of the screen. I then found that the blue was matched in a rotator by a disk having a sector of 60 parts of the circumference of Prussian blue, with a sector of 10 parts of emerald-green and a sector of 30 parts of white cardboard. The blue was that of one of the many colored disks given me by Professor O. N. Rood and was marked, "Blue between cyan-blue and the ultramarine of the physicist, but nearer the latter. Near F and on its more refrangible side. Made with Prussian blue." The blue on this disk appeared as saturated in hue as could be made by the pigment.

The match of the color of the side of the ring facing the lamp, L in fig. 3, was obtained by placing a silvered mirror, M, so that the reflection of this side of the ring, S, was seen close to the rotator, R.

The color of the cardboard ring facing the lamp was matched by the rotation of a disk formed of 50 parts of chrome yellow, 30 parts of red lead (red orange) and 20 parts of white cardboard. Such appears to be the hue of the light of a petroleum flame when compared, in this manner, with the light of the sun.

The petroleum flame used in these experiments was that of a Belgian burner, giving about 35 candles. The daylight was obtained from a window 85^{cms} square; the lower half of which when viewed from the screen, was occupied by the snow-clad surface of an opposite hill. The day was very clear, and the sky very slightly tinted with blue.

Fig. 3.

The colors of the sides of the ring of the screen are complementary. — I combined the Prussian blue, emerald green, chrome yellow and orange red on a disk on the rotator and found that when the disk was formed of sectors having 60 parts of Prussian blue, 11 of emerald green, 19 of chrome yellow, and 10 of red lead, I obtained a gray which was exactly matched by a central disk formed of 71 parts of dead ivory-black and 29 of white cardboard. See fig. 2. These measures gave the following equation:

$$\left\{\begin{matrix}60\text{ Prussian blue}\\11\text{ Emerald green}\end{matrix}\right\} + \left\{\begin{matrix}19\text{ Chrome yellow}\\10\text{ Red lead}\end{matrix}\right\} = \text{Gray}\left\{\begin{matrix}71\text{ Black}\\29\text{ White}\end{matrix}\right\}$$

It is rather difficult to get the exact match on the rotating disk of the hues on the front and back of the card-board ring of the screen on account of the illumination of these surfaces. The rotator must be placed nearer the window than the screen so that it is well illuminated.

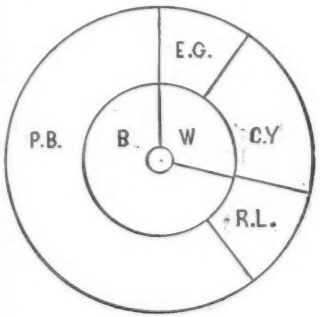


Fig. 2

The equation shows that the cyan-blue of 60 parts of Prussian blue + 11 of emerald green is complementary to an orange yellow of 19 of chrome yellow + 10 of red lead. The hue of this orange of the lamp side of the ring, as given by the rotator was 50 chrome yellow + 30 red lead + 20 white, which mixture is approximately in the proportion of 19 to 10. The correspondence of the two experiments is, I suppose, about as near as could be expected from the difficulty of matching the illuminated hues of the ring of the screen.

The small central disk on the rotator gave a gray of 71 parts of ivory-black + 29 of white cardboard, which matched the gray given by 71 parts of cyan-blue + 29 parts of orange.

Calling the intensity of the orange 100, we have $100 \times 29 = 71$ I, which gives for I (the intensity of the cyan-blue), only 40·8 per cent of that of the orange.

Fig. 4.

The orange yellow of the side of the ring facing the lamp and of the side of the translucent paper facing the daylight is complementary to the cyan-blue of the side of the ring facing the daylight and of the side of the translucent paper facing the lamp.

In fig. 4, L is the lamp; S, the screen which in this experiment is deprived of the border of translucent paper; W, the window; M, a silvered mirror which reflects the back of the screen to the eye which looks through an achromatized double refracting calc spar prism at C.S., and sees two images of the side of the screen reflected from the mirror and two images of the side of the screen facing the window. By suitably inclining and rotating the calc spar prism these images may be brought into the positions shown in fig. 5, in which A represents one of the images of the side of the screen facing the window; B, the other image of the same; C, is one of the images of the side of the screen facing the lamp and seen by reflection from the mirror.

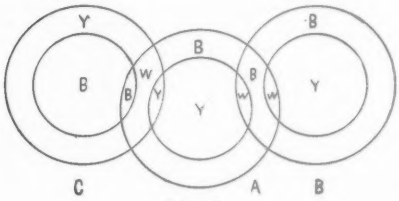


Fig. 5.

The overlapping of these images, when the illumination is properly adjusted, gives the following results, as shown by the letters in fig. 5, where B stands for cyan-blue, Y for orange yellow, and W for white. The translucent paper Y of B overlaps the ring of A and gives white, and the blue of the ring of B overlaps Y of the translucent paper of A and gives white. In the same manner the orange yellow of the cardboard ring of C overlaps the blue of the ring of A and gives white. Where the ring of C overlaps the translucent paper of A there is a more intense orange, and when the blue of the translucent paper of C overlaps the blue of the ring of A we have a more intense blue. On bringing B of the translucent paper of C over Y of the translucent paper of A we have white.

Experiments on the complementary colors of gratings.—Out of thin cardboard, such as is used for thin visiting cards, I cut

gratings with a dividing engine. See fig. 6. The widths of the spaces cut out of these gratings exactly equalled the breadths of the cardboard left in the grating. Gratings were thus made having spaces of 1, 2, 3, 4 and 5^{mm}. The cardboard is rendered opaque by coating one side of it with ivory-black in dilute shellac varnish. After it has dried the cardboard is well flattened before it is fastened to the surface of a piece of hard wood on the dividing-engine. The cutting edge of the cutter for this work must have a very acute angle. I made one by grinding down a rod of Stubs' steel. Heating this to a dull cherry red and then forcing it into a large ball of beeswax gives the edge of the cutter the required temper, without the necessity of subsequently "letting it down." The blackened side of the gratings was covered with the "Alba tracing paper." The grating was mounted back of an opening in a black cardboard screen, so that only the white grating was exposed. Two other black screens, Wh and Y of fig. 7, having openings of the same size as the grating and covered on the back with the translucent paper, were placed on either side of the grating, G. In fig. 7, L is the lamp. The window is on the other side of G. The screen S divides the apparatus so that the light of the window W reflected by the mirror M on to the screen Wh cannot fall on G or on Y, which are only illuminated by the lamp L.

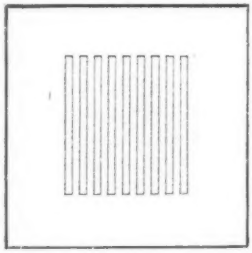


Fig. 6.

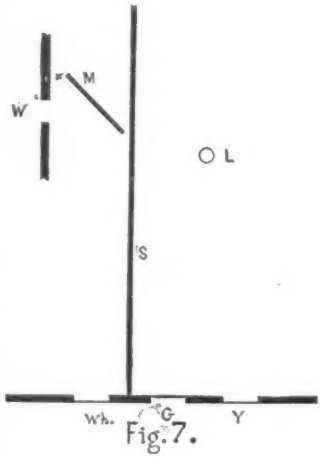


Fig. 7.

The translucent paper of the grating G and of the screen Y appear orange yellow. The bands of white cardboard of the grating appear cyan-blue. The translucent paper of the screen Wh is white.

Sit a little to one side of the grating so as not to intercept the light from the window, and look at the grating through the calc-spar prism. Rotate it till the blue bands of the grating are superposed on the orange bands, when, if the surface of

the grating is equally spaced, the superposed surfaces appear white when compared with the white of the screen Wh. Without the screen Wh the eye has no term of comparison and may take a yellowish white for white. The illumination of the screen Wh should be made equal that of the superposed images of the grating.

When this experiment is carefully made, with the proper illumination, the effect is surprising when, in favorable conditions, on rotating the prism you see the grating actually obliterated with no bands visible, but only a uniform white surface. The grating with spaces of 3^{mm} gave the best results:

In experiments with the screen, fig. 1, formed of the cardboard ring and the translucent disk, it is easy, by altering the relative intensities of the daylight and lamplight and by changing the distance of the lamp from the screen, to produce great changes in the saturation of the contrast-colors. Indeed I have sometimes thus obtained, towards nightfall, a cyan-blue so saturated in hue that little or no white was required in the disk of the rotator to match the color on the ring. In the same manner similar changes in color have been observed in the hue of the ring illuminated by the lamp.

On illuminating one side of the screen by daylight and the other by the white light of a Welsbach incandescent lamp, and then placing colored glasses or films of colored gelatine between the screen and the Welsbach lamp effects of contrast are obtained which are so readily imagined by the physicist as to require no description; but they are worth viewing.

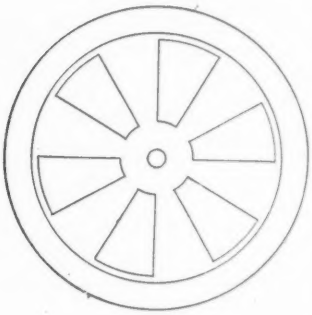


Fig. 8.

Increase of the purity and luminosity of the contrast colors by a rotating screen.—Make a disk of white cardboard of 27^{cms} in diameter, with eight sectors cut out of it, and cover it with translucent paper so that the paper extends beyond the disk and makes a border 3^{cms} wide. A circle of 8^{cms} in diameter is left in the center of the disk and a ring of $1\frac{1}{2}^{cm}$ on its border. This disk is shown in fig. 8, but with only six sectors. It should have eight. It is placed between the lamp and the window, and rotated with a velocity of one revolution in about $1\frac{1}{4}$ seconds, while it is viewed on the side facing the window. The blue sectors thus take successively the places just before occupied by the sectors of orange-yellow and the effect is to

heighten the contrast-color in such a remarkable manner that the blue sectors by their more intense color appear separated from the rim and central circle appear in a plane farther from the eye than the plane of the center and rim. On the side of the disk illuminated by the lamp the same effects are produced, only they appear more marked. A change will also be observed in the hue of the advancing and following edges of the sectors, on both sides of the disk; the advancing edges appearing more saturated in hue than the following edges.

A mode of observation by which contrast-colors are intensified.—Simultaneous contrast-colors are generally viewed by placing gray or tinted surfaces on colored grounds, or by the juxtaposition of colored surfaces. The effects thus produced are of such constant occurrence in the paintings of artists, and in colored fabrics, that their study is of great interest. The contrast-colors thus produced have generally been studied by simply placing on a colored ground smaller gray or tinted surfaces and observing these with the unaided eye. This method has been improved by H. Meyer* who viewed the gray on the colored ground when both were covered with white transparent paper.

The mode of observation I have devised for the study of contrast-colors is as follows. A glass tube of 2·7^{cms} in interior diameter and 10^{cms} long is coated on the outside with black Japan varnish, so as to have reflection only from the interior surface of the tube. A ring of 3^{cms} in diameter with a central opening of 2^{cms} is cut out of gray paper. The gray of this ring was matched on the rotator by a disk having 57 parts of ivory-black and 43 parts of white Bristol board. This ring, placed on a surface of emerald green appears of a rose color. If at the distance of distinct vision we look at the ring through the tube we shall see the ring by direct vision inclosing a circle of green and surrounded by a ring of emerald green, and this inclosed by a rose colored ring, produced by reflection from the interior of the tube, and surrounding this ring is another of emerald green, as shown in fig. 9; in which R and R are the red rings and G, G, and G, the circle and the two rings of emerald green.

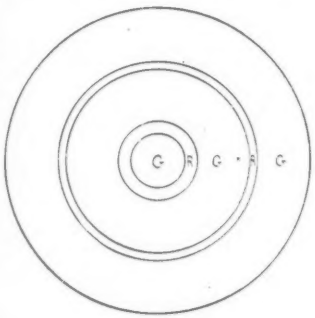


Fig. 9.

* Pogg. Ann., xcv, 170.

The hue of the rose-colored rings as seen through the tube is much more intense than the hue of the ring viewed on the emerald ground with the unassisted eye. Experiments made with the aid of an achromatized calc spar prism, and by matching on a rotating disk the colors of the gray ring on an emerald green ground showed that the intensity of the contrast-color, as seen with the reflecting tube is nearly double of what it is when viewed by the eye alone. The color of the ring when viewed by the unassisted eye was matched on the rotator by a disk having 30 parts of Chinese vermillion + 7 of "Hoffman's violet R. R. R." + 34 parts of ivory-black + 29 of white Bristol board. As seen through the reflecting tube the match appeared to be given by 57 of Chinese vermilion + 15 of "Hoffman's violet R. R. R." + 28 of white Bristol board.

Another tube, 4·5^{cms} in diameter and 18^{cms} long gave excellent results, with two reflected rings, and on nearer vision, with four reflected rings. A tube, suitable for these experiments, is selected by closing one of its ends by a disk of cardboard having a pin hole at its center. When the end with the pin hole faces the sky and we look through the other end we see bright rings caused by the reflection of the light of the pin hole from the surface of the tube. If these rings are circular and concentric the tube is of circular section and its axis is a right line.

The value of this mode of observation is shown by the following experiments. Place the ring of gray paper, or, a circle of gray paper, about 1½^{cms} in diameter, on a surface painted with cobalt blue, not too saturated. The gray ring, or, circle, appears of an orange tint. Place a similar gray ring, or, circle, on a surface lightly washed with emerald green, it appears pinkish. The difference between the hues of the ring when viewed on the cobalt blue and on the emerald green though decided is not strongly marked; but if viewed through the reflecting tube the ring on the cobalt blue appears of a rather intense orange and the ring on the emerald green appears of a rose color. When so viewed the difference in these hues is strongly marked.

Pieces of card-board, painted with the following colors, were arranged in pairs. Orange yellow on the less refrangible side of D, and orange yellow on the more refrangible side of D. Greenish yellow and yellowish green, both made with gamboge and Prussian blue. Purple of violet end of spectrum with added red, made with Hoffman's violet R. R. R., and violet between G and H, Young and Müller's fundamental color. Place a pair of the colors, as given above, side by side and on each put a gray ring, with a reflecting tube over each

ring. When viewed by the unassisted eye the differences in hue are slight and difficult to define; but when viewed in rapid succession through the adjoining tubes the differences in hue are decided and may be readily matched in color with disks on the rotator.

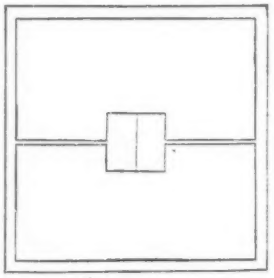


Fig.10.

The duration of the time of vision necessary to perceive contrast-color.—A square screen was made, as shown in fig. 10, with a square of cardboard in its center, 8^{cms} on the side, surrounded by a square of translucent white paper, 35^{cms} on the side. This screen was placed between the petroleum flame and the window so that its sides were equally illuminated. On the side facing the window the central square appeared cyan-blue. One-half of this square was covered by a strip of paper so tinted with orange yellow that it appeared gray when in juxtaposition with the other blue half of the square.

On a rotator was placed two superposed black disks of the same diameter (25^{cms}). Near the periphery of each disk was cut out an annular slot, 4^{cms} long and 6^{mm} wide, as shown in fig. 11. By turning one of these disks on the other the opening of this slot could be varied from 4^{cms} to nothing. The rotator is so made that the time of a rotation of the disk can be held uniform and also accurately measured. On gradually narrowing the opening in the slit the duration of vision of the blue and gray square was reduced to $\frac{1}{1600}$ of a second, when the blue half of the square could not be distinguished from the gray half.

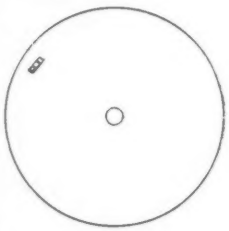


Fig.11.

When the screen was illuminated by a more orange light, obtained by placing a sheet of orange gelatine between the lamp and the screen, the gray and blue were not distinguishable when the duration of vision was $\frac{1}{1300}$ of a second.

In these experiments I only got 11·6 flashes of light from the screen in a second, while the number of flashes required to banish all flickering from the screen was accurately measured as $\frac{1}{46}$ of a second with the illumination of the lamp alone, and $\frac{1}{42}$ of a second when the lamp-light traversed the orange gelatine film. These experiments show, what is well known, viz: that as the intensity of the light diminishes the duration

of no perceptible change in the intensity of the residual impression increases. I found that the light from a white cloud, seen, near noon, through a north window on a clear day lasts only $\frac{1}{68}$ of a second before the residual effect diminishes.

A gray ring was placed on an emerald green ground facing the light from a bright white cloud. When viewed through the opening in the rotator the ring appeared pink on the green ground till the duration of the vision of the ring was reduced to $\frac{1}{83\,80}$ of a second, when the ring ceased to be visible on the emerald green ground; but so long as it was visible the contrast color was visible. I found that 43 flashes per second were necessary to render the vision of the pink ring and green ground steady, without the least flickering, while only 11·6 flashes per second were obtained in determining the $\frac{1}{83\,80}$ of a second as the time when contrast-color ceased to be visible. The fact that the contrast color of the ring remained till the ring could not be distinguished from the green ground gave the opinion that I ceased to obtain contrast-color because the narrow slit used gave too little light to the eye. On doubling the width of the slit and doubling the velocity of rotation the contrast-color of the ring reappeared, though the duration of vision was the same as in the former experiment.

Experiments on simultaneous contrast-colors produced by the flash of the electric discharge.—The foregoing experiments having proved insufficient to form any opinion as to the time of vision necessary to perceive simultaneous contrast-color I made the following experiments with the light obtained by the discharge of a Holtz induction machine.

The gray ring was placed on the emerald green ground near a Holtz machine, which gave a very bright flash of 8^{cms} long. The condensing surface on the two jars connected with the electrodes of this machine equalled 135 square centimeters. Professor O. N. Rood* measured the duration of the flash of Leyden jars of 738 and 71 square centimeters of surface, charged by an inductorium. The durations of the discharges of these jars were respectively $\frac{1}{5,700,000}$ second and $\frac{1}{28,000,000}$ of a second. From these measures I infer that the duration of the flash of the Holtz machine did not exceed the $\frac{1}{100,000,000}$ of a second. With short striking distances between the electrodes the flash is formed of several separated acts, as shown by Henry,† Feddersen,‡ Rood,§ and Mayer.‖ In the case of the discharge of a large inductorium the writer(‖) has shown that when the striking distance between brass ball electrodes is only one millimeter, with a Leyden jar of $242^{sq\ cms}$ of sur-

* This Journal, Sept., 1871
‡ Pogg. Ann., vol. cxvi, p. 132.
‖ This Journal, Dec., 1874.
† Proc. Amer. Phil. Soc., 1842.
§ This Journal, Oct., 1872.

face in the circuit, the discharge lasts $\frac{1}{24}$th of a second and is formed of over 120 separate sparks; but as the striking distance is increased the discharge is formed of fewer and fewer components, till at a striking distance between 1 and 2^{cms} the discharge is reduced to a single flash. In the following experiments the striking distance is 8^{cms}, and a single flash was given, whose duration we may safely assume was less than $\frac{1}{1,000,000}$ of a second.

In a dark room, at night, the flash of this machine gave vivid contrast-colors. The gray ring appearing bright pink on an emerald green ground, and of a bright yellow on an ultramarine ground. The after images of these effects lasted about $\frac{1}{2}$ of a second.

A rod was placed in front of a white cardboard and the shadow of the rod was formed on the screen by a candle. The distance of the candle was such that the white cardboard appeared equally brilliant when illuminated only by the candle, or, only by the electric flash. At the moment of the flash the appearance presented was very remarkable. From the shadow of the candle appeared suddenly to shoot a dark screen, which had superposed the shadow of the candle, and which shot to the side of the shadow and appeared of a bright golden orange, while the apparently uncovered shadow of the candle appeared of a brilliant cobalt blue; to my eye exactly as though an opaque screen had been suddenly removed from a slit in the shutter of a darkened room, which slit was covered by a piece of cobalt glass.

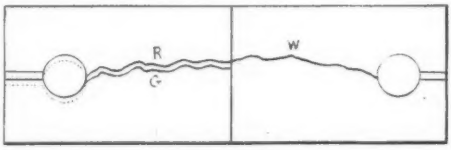


Fig. 12.

A square of thin green glass, 4^{cms} by 6^{cms}, was placed on a piece of thin silvered glass, 4^{cms} by 12^{cms}, so that the edges of the green glass and of the silvered glass coincided. This arrangement gave a surface, half of silvered mirror, half of green glass. This apparatus was so placed that the electrodes of the machine and the flash were reflected from it to the eye. The room was dark. At the moment of the flash its reflection appeared as in fig. 12. On the mirror the line of the discharge was white; W in the figure. The continuation of this line on the surface of the green glass appeared red (R in figure), though really white. In front of and parallel to this line was a green line, G, produced by the light of the flash reflected from the surface of the silvered mirror, and having traversed

twice the thickness of the green glass. In this experiment we obtain contrast-colors in the source of light itself.

The explanation of the phenomena of simultaneous contrast-colors, as generally given in works on chromatics, is that they are due to "error of judgment," to "deception of judgment," or to "fluctuation of judgment." The reasoning given may be convincing if all the conditions really exist which the writers assume to exist in their explanations of these phenomena. One of these conditions is that a judgment can be formed in the minute interval of time only necessary in which to perceive contrast-colors. In the experiments just described with the electric flash we have *apparently* instantaneous perception of the contrast-colors in the gray ring placed on the green and ultramarine grounds, in the candle and electric light shadows and even in the very flash itself when this is seen reflected from the top surface of a green glass and from the mirror on which the green glass rests.

Many careful experiments made by me and others, using as chronometer three pairs of forks of the octave of UT_6, giving respectively 10, 12 and 15 beats per second, showed that certainly the interval between the flash and the perception of the colors was much less than $\frac{1}{15}$ of a second. Indeed, on viewing the flash and the illuminated surfaces at the same time, or, hearing the discharge and viewing only the illuminated ring, *no interval could be detected* by this mode of observation as existing between the instant of the flash and the perception of the colors, and we certainly could have detected a shorter interval than $\frac{1}{15}$ of a second had it existed.

Incidentally, I will here state that when different geometrical or irregular figures cut out of white paper and placed on an ivory-black ground were illuminated by the electric flash, the observer, so far as I could ascertain formed conclusions as to the forms of the pieces of paper in an interval of time less than the $\frac{1}{10}$ of a second. Certainly the interval of time required to reach a conclusion as to the contrast-color was less than the $\frac{1}{15}$ of a second. Professor Mendenhall in 1871 (this Journal) gives 0·292 sec. for the time required by an observer to respond, by means of an electric chronograph, to the appearance of a white card. When the observer responds by touching the circuit key with one hand when a white card appears, and with the other hand when a red card appears, Professor Mendenhall finds 0·443 sec. as the time required for the response. Subtracting the first number from the last he obtains ·151, or $\frac{1}{6}$ sec., as the time to form a judgment between white and red. Similar experiments gave him 0·202, or $\frac{1}{5}$ sec., as the time to judge whether a circle or a triangle appeared to the observer. The intervention of the

operation of brain, nerve and muscle before the response is recorded involves complex operations, and the action of right or left sides of brain when the two hands are used. It appears that the plan of eliminating these actions and thus obtaining a residual time which is attributed to the interval required to form a judgment of color or of form is faulty. I am sure that if estimation of the time required for such mental operations is made by the *continuous indications* of the beats of forks, such intervals as $\frac{1}{6}$ and $\frac{1}{9}$ of a second will at once appear much in excess of the time respectively required to form a conclusion as to whether a white or red color or a circle or triangle has been presented to our vision.

It is here to be noted that although the after-images in these experiments with the electric flash lasted about $\frac{1}{2}$ of a second, yet the most careful scrutiny could detect no change in sensation at and immediately following the flash. The contrast-colors, so far as I and others observed, appeared at the moment of the flash. After the instant the image of the flash is formed on the retina there exists, no doubt, an interval of time before we are conscious of the stimulus, whose effects are seen rapidly to rise and then more gradually to fall, falling with two oscillations in intensity, so that all the events of the phenomenon take place in about $\frac{1}{2}$ of a second. However, no vague impression of surfaces merely differing in illumination and then suddenly changing into a color and its contrast-color could be detected. I think that this interval of no color sensation, if it exist, must be of exceedingly short duration; but such a period of light without color cannot be detected, and if it cannot be perceived, then, so far as we are concerned, it appears to me, that there can be no hesitation in the perception of the colors, and no "fluctuation of the judgment" and "dividing between two images the difference in color which really exists" before the mind reaches its conclusion as to the character of the colors.

The following experiments were separately made on three persons between whom no communication had passed as to the nature of the experiments to be tried on them. I placed a gray ring on a ultramarine disk in front of the Holtz-machine and requested the observer, who had implicit confidence in my truthfulness, to describe to me as accurately as possible the exact hue of the pink, or rose color, or red he would see on a green ground at the instant of the electric flash. Each observer at once said: "it is not pink, the ring appears yellow on a blue ground." Now in each of these experiments the observer was prepared, by my pardonable lying, to see red on a green ground, and to see yellow on a blue ground his mental condition of anticipation to see red on a green ground was first

removed then a new departure was taken and a judgment formed which resulted in his seeing yellow on a blue ground, and all that in a minute interval of time.

I do not know if psychologists have come to a conclusion as to the smallest interval of time necessary to form a judgment, either true or false, or in which to have a "fluctuation of the judgment," or in which "to exercise judgment and divide between two colors the difference in colors which really exist." If such mental operations can be performed in the millionth, the thousandth, or even in a few hundredths of a second then the explanations of these phenomena, as generally given, may be convincing.

Von Bezold in his "Theory of Color," Boston, 1876, in explaining the fact that a rod seen by reflection from a piece of green glass laid on a mirror gives two images one green the other red, says: "As the observer does not *know* which of the two images is the colored one he exercises his judgment, and divides between the two images the difference in color which really exists." Now this experiment is similar in its conditions and in its effects of contrast-color to the one I made on the contrast-colors of the electric flash, when the same colors were distinctly seen apparently at the moment of the discharge. Can one "exercise his judgment and divide between the two images the differences in color which really exists" in an interval of time which is less than $\frac{1}{10}$ of a second?

In the experiment of the colored shadows cast by the candle and by daylight, these colors are explained by Von Bezold (pp. 152, 153), as follows: "The spot occupied by the blue shadow is illuminated by the *white daylight*, the larger white surface by *daylight and by candle light*, the other shadow by candle light only. It might be presumed, therefore, that one of the shadows would appear white the other yellow. This is not the case, however; for *knowing* the surface to be white we still take it to be white after it has really received the yellow light of the candle. Our judgment is led astray regarding white, and hence we believe the place occupied by the second shadow to be blue, although it is actually white." Helmholtz ("Lectures," N. Y., 1873, p. 267), says: "Thus in the experiment described above of colored shadows thrown by day-light and candle light the doubly illuminated surface of the paper being the brightest object seen gives a false criterion for white. Compared with it, the really white but less bright shadow thrown by the candle looks blue." These explanations assume knowledge and conditions which are not essential. If this knowledge and these conditions were necessary to see the phenomena then these explanations of the phenomena might be convincing; but the conditions they assume are not necessary.

The following experiments show that there is no necessity at all in "knowing the surface to be white" or to see "the doubly illuminated surface of the paper."

The experiment of the colored shadows cast by the candle and by daylight was arranged behind a screen, so that no one could divine what was there. A tube blackened on the inside went obliquely through the side of the screen and was so adjusted that the circular field of view through the tube was entirely filled by equal portions of the two shadows, which formed two semicircles, one colored orange the other blue. The two persons on whom I experimented were ignorant of the phenomena of contrast-color and moreover were misled as to what they would see on looking into the tube, and I was specially careful not to speak to them about color. These persons were strangers to each other and neither knew that the other had been the subject of my experimenting. The first observer at once reported: "I see a circle half yellow and half blue." The other said: "I see a golden band next to a sky-blue band and the golden band is rather deeper in color where it is next to the blue," which is certainly a very good description.

Having in mind the facts established by the foregoing experiments it seems to me that we have either to regard the phenomena of simultaneous-contrast color as psychical phenomena of which no satisfactory explanation has been given, or, we must discard the Young–Helmholtz hypothesis of color sensation and adopt one similar to that of Hering, which gives a direct physiological explanation of contrast-color effects without the psychological considerations which those who adopt the Young–Helmholtz hypothesis are obliged to resort to in their explanation of these phenomena; and which explanations, as I have attempted to show, are faulty, and have to be modified to be convincing.

According to Hering's hypothesis of color sensations when a portion of the retina is stimulated, adjoining portions of the field of view are affected by a sort of inductive action; so that changes are produced which are antagonistic or complementary to those portions of the retina actually stimulated.

M. Foster in his "Physiology, Lond., 1891," Part IV, bk. III, gives an excellent discussion of the relative merits of the Young–Helmholtz hypothesis and Hering's in explaining color sensations. In conclusion he writes . . "so far as we are aware no crucial test between the two has as yet been brought forward. We may now leave the matter with the remark that while the Young–Helmholtz theory tends to lead us direct from the retinal image to the psychological questioning of the sensations, and seems to offer no bridge between the

first step and the last, Hering's theory is distinctly a physiological theory, and at least holds out for us the promise of being able to push the physiological explanation nearer and nearer home before we are obliged to take refuge in the methods of psychology."

A Photometer for measuring the intensities of differently colored lights.—It has already been shown that, in certain conditions of illumination and in certain directions of sight, a screen formed of perforated cardboard covered with translucent paper appears with complementary colors, and that if the screen be in the form of a disk with alternate sectors cut out of it, and is illuminated on one side by daylight and on the other side by lamplight, that the blue of one side of the disk and the orange of the other appear intensified on slowly rotating the disk. On increasing the velocity of rotation the complementary colors gradually blend and when the velocity of rotation has banished all flickering light from the disk it appears nearly white. The side facing the daylight has a slight yellowish tint; the side facing the lamp appears whiter, but is tinted with a feeble bluish hue.

To study more minutely these phenomena I made a disk which could be readily taken apart and mounted with different translucent papers and have attached to it disks and rings of various colors. I shall call this disk, *the photometer disk*. It is made as follows:

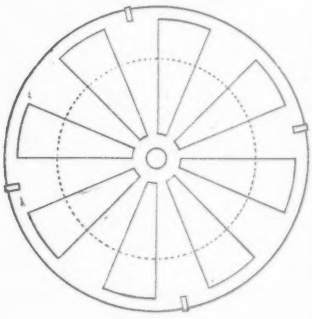


Fig. 13.

Two disks, 13^{cms} in diameter, and having eight sectors cut out, as shown in fig. 13, was made of thin Bristol board. A circle of 2^{cms} in diameter was left in the center of the disk, from which the cardboard sectors radiate. The border of the disk is a ring of $\frac{1}{2}^{cm}$ wide, which was painted black. Clamps, made of thin hammered brass, held these disks together.

Between these disks was placed a circle of the same white translucent paper used in the construction of the large contrast-color screen, fig. 1, and the disks were clamped together with the open sectors of the two disks coinciding in position. A black disk of 8·2^{cms} in diameter was placed on each side of the photometer disk, thus leaving between it and the black peripheral ring an annular space of 1·9^{cm} wide, formed of alternate spaces of cardboard and of translucent paper. The disk

505 a5 J |

was mounted on a rotator and placed opposite two silvered mirrors inclined at an angle of 150°; an arrangement similar to that of Letheby for observing the disk of Bunsen's photometer. The plane of the disk of the rotator bisected the angle formed by the mirrors, as shown in fig. 14, so that the surfaces of both sides of the disk could be seen simultaneously, or, rather, in rapid succession. On rotating the disk while illuminated by daylight on one side and by lamplight on the other, the side illuminated by daylight appeared white tinted with yellow; the side facing the lamp appeared white tinted with blue. The hues were the same as described in the experiment with the large disk, fig. 8, only the surfaces appeared brighter by contrast with the black center and border.

Fig. 14.

The feeble character of the hues on the photometer disk led me to hope that I could bring these to the same hue on both sides of the disk by the effects of contrast. To accomplish this I placed on the daylight side of the photometer-disk a compound disk formed of three split disks, one of red lead, one of chrome yellow, the other of white Bristol board. On the lamplight side I placed a disk formed of three split disks, colored ultramarine, emerald green, and one of white Bristol board. On rotation, the compound disk on the daylight side gave an orange yellow; on the lamplight side the disk gave a bluish green. These colors corresponded in hue to those seen on the respective sides of the ring of the photometer disk when it is rotated, only the hues were much more saturated. After a few trials I brought, by the contrast effects of these colored disks, the tints on the two sides of the ring of the photometer to the same hue; the translucent ring appearing white with a very slight orange yellow tint on both of its sides. The greenish blue had by contrast effect obliterated the blue tint of the ring and even replaced it by a very feeble orange yellow; while on the other side of the ring the orange yellow disk had diminished the orange yellow tint of the ring to the same feeble orange yellow as seen on the other side of the ring.

Experiments were now made to test this apparatus as a photometer. Equality of illumination cannot be determined with any precision if the two surfaces compared differ even slightly in hue. Here we had the same hue to deal with on both sides of the ring; which condition is different from the Bunsen photometer on which we have two colors on each side

of the disk. Various methods were tried to render reliable the comparison of the illumination of the two sides.

(1) I used the eye alone, regarding only the portions of the ring on the border near the mirror, as shown in fig. 14.

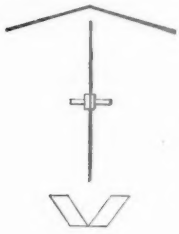


Fig.15.

(2) Two prisms reflected the images of portions of the sides of the ring nearest the mirror to juxtaposition, as shown in fig. 15.

(3) A tube blackened on the inside, with a black screen on the end next the disk, as shown in fig. 16, was used. The eye was thus shielded from extraneous light and the comparisons of illuminations was made, as in experiments 1 and 2, on the portions of the rings which were nearest the mirror as shown in fig. 16. Vision through this screened tube gave the best results.

After practice in such comparisons, made during several hours on different days, I became more and more skillful and the results of measurements become more concordant; but such methods of photometry do not approach the accuracy of those in which two contiguous surfaces of different degrees of translucency coalesce into one surface of a uniform illumination, as happens on the balance of illuminations on the two sides of a Bunsen photometer disk when these are illuminated by lights of the same intensity and of exactly the same hue. A photometer for this mode of observation is described in the following section. It has, however, the advantage over the Bunsen photometer in that it serves to measure the intensities of differently colored lights.

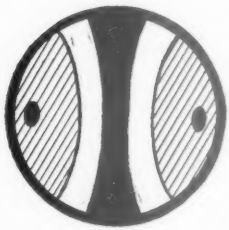


Fig.16.

The Rotating-Disk Photometer.—The photometer disk was taken apart and a ring of thin white linen paper* of the diameter of the disk and $\frac{9}{10}^{cm}$ wide was laid on one of the disks; this was covered by the circle of thin translucent white paper and on this was laid another ring of the thin linen paper. The disks were now clamped together. The outer portions of the open sectors of the disk were thus closed by two thicknesses of the thin linen paper with the "alba tracing-paper" between them, *a*, in fig. 17; while the inner portions of the sectors were closed by the tracing-paper alone, *b*, in fig. 17.

On rotating the disk, it was not possible to balance the colors of the outer half (*a* in fig. 17), of the ring formed of

*The best paper I have experimented with for this purpose is water-marked "Crane & Co., Dalton, Mass., Bond, No. 21."

three thicknesses of paper, with the same central colored disks, used in the previous experiment, when one side of the disk was illuminated by lamplight, the other by daylight. But on increasing the saturation of the hues of the central disks and adding peripheral rings of the same hues, I succeeded in making the hues the same on both sides of the photometer ring. If equality of hue can be obtained when the photometer is illuminated, on one side by lamplight and on the other by daylight, then the contrast-colors may be brought to the same hue when the photometer is illuminated on one side by a candle or petroleum flame and the other side by the electric arc light or by the whitest Welsbach incandescent lamp.

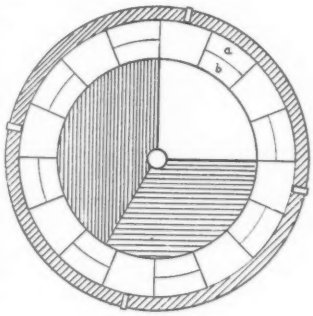


Fig. 17.

With a change of distance of the petroleum flame from the photometer the differences in the illumination of the portions *a* and *b*, fig. 17, of the ring were changed. When the two sides of the ring were equally illuminated the rings *a* and *b* appeared indistinguishable, fusing into one ring of uniform tint and illumination, of the breadth of $a + b$.

With the best Bunsen photometer disk* I was unable to decide where it received equal illumination on its sides, so difficult was it to judge of equal brightness of the blue and orange on one side when compared with the orange and blue in the same respective positions on the other side of the disk.

With a petroleum flame of 40 candle light-giving power on one side of the rotating photometer and a candle on the other, the delicacy of the indications of the rotating photometer equalled, and even slightly excelled, those of the very best Bunsen photometer disk.

If we bring in succession the translucent sectors of the rotating photometer disk between two lights we observe that, on certain sectors, *a* and *b* appear as one surface of the same uniform tint and illumination; on other sectors sometimes *a*, sometimes *b*, is the brighter. Rotation of the disk entirely destroys such slight differences and the disk then acts as if made of absolutely homogeneous material, placed in the same conditions of contact of the layers of paper, in each translucent sector.

* The best Bunsen photometer disks I have used are those sold by the American Meter Company of N. Y. They are made in England.

The hue of the light of "a white incandescent Welsbach lamp" compared with daylight.—When the screen, fig. 1, is illuminated on one side by the Welsbach lamp and on the other by daylight, the side of the ring of the screen facing the daylight appears a feeble blue decidedly tinged with violet. The side of the ring facing the Welsbach lamp is colored greenish orange. This greenish orange was matched in hue, but not in luminosity, by a rotating disk having 41·5 parts of red lead, 41·5 of chrome yellow and 17 of emerald green, viewed illuminated by daylight. This appears to be the hue of the Welsbach light when compared with daylight.

Experiments in which are compared the hues of the light of an incandescent Welsbach lamp and of candle light.—When "a white-light incandescent Welsbach lamp" is placed on one side of the large screen, fig. 1, and a candle, or petroleum flame, on the other side, the cardboard ring of the screen facing the Welsbach light appears of a light bluish green; the side of the ring facing the candle, or petroleum flame, appears of a light carmine.

Matching these hues on the rotator with split disks gave the following results when the two sides of the screen were equally illuminated. The hue of the ring on the side facing the Welsbach lamp was matched by 8 parts of emerald green, 10 of cobalt blue, 25 of ivory black and 57 parts of white Bristol board, as seen illuminated by the Welsbach lamp. The hue on the side of the ring facing the candle or petroleum flame was matched by 12 of carmine, 17 of ivory black and 71 of white cardboard, as seen illuminated by the petroleum flame.

Experiments with the rotating-photometer disk placed between the Welsbach lamp and the petroleum flame.—On rotating the photometer disk, without any central disks, between these lights, the same hues as those already described were seen on its sides, only these hues were much less saturated.

The white disks placed on the sides of the rotating photometer made the hues less saturated.

With a white disk on the petroleum flame side and a black disk on the Welsbach lamp side the difference between the hues of the sides of the photometer were more pronounced.

With a disk of cobalt blue, emerald green and white on the Welsbach-light side and a white disk on the petroleum flame side, the side of photometer facing the Welsbach lamp appeared white and the side facing the petroleum flame was less carmine; the differences in hue being less than in any of the previous experiments.

By trial I found that when a disk of 33 parts of emerald green, 42 of cobalt blue and 25 of white was placed on the Welsbach lamp side of the photometer disk, with a ring of the

same hue on the periphery and a disk of 75 parts of carmine and 25 of white was on the petroleum flame side of the photometer disk, with a ring of the same hue on the periphery of the photometer, that the sides of the photometric ring of the photometer had the same hue; which was white tinged with just a perceptible carmine.

We are now in condition to make an interesting experiment which shows in a striking manner the effects of the colored central disks and peripheral rings on the colors of the photometric ring of the photometer. The exact balance of hue on both sides of the photometer has been obtained. Reverse the photometer disk with its central disks and rings and rotate the disk in front of the mirrors. We now see the photometric ring with strong contrast of color on its sides, and the concentric rings *a* and *b* are separately seen, not appearing indistinguishable as in the previous experiment. By the reversal we have, by the effects of the disks and rings, added to the effects produced alone by the lights.

It is to be noted that the colors on the disks and rings of the photometer must not be too saturated in hue. The elementary disks of these compound color disks should be made of thin Bristol board and after they have been painted should be well flattened before they are slit radially. After the proper hues have been obtained for the disks which correct the color of the photometric ring, the same hues should be painted on single disks, which are subsequently flattened. The thinner the color-correcting disks and the closer they fit to the photometer disk the greater is their contrast color-effect. The colored rings must be cut out of the painted cardboard, for if the rings are painted after they are formed it is very difficult to make them flat.

To render easy the making of this photometer I made experiments so that one could get the proper hues of the correcting disks and rings by mixtures of definite weights of the pigment powders and definite volumes of gum-water; but it is less troublesome to paint a few disks with colors variously saturated and repeat the experiments I have described, and thus furnish oneself with the sets of disks and rings necessary for the photometric measures of the arc electric light, of the Welsbach white burner, etc., when compared with the standard candle or petroleum flame.

The rotator on which the photometer-disk is revolved should be made as shown in fig. 18, so that the standard, S, and the pulley, P, which is driven by the wheel, W, shade as little as possible the rotating disk.

Photometric measures with the Rotating-Disk Photometer.—On one side of the photometer was placed "a white Wels-

Fig. 18.

bach burner" with a light-giving power of 33 candles, on the other side a standard candle. As the candle was gradually brought nearer the rotating photometer the illumination and hues of the portions *a* and *b* (fig. 17) of the photometric ring approached equality and when the candle was at a certain distance the difference of illumination and hues of *a* and *b* become indistinguishable and only a band with a breadth of *a*+*b* with a uniform surface was observed on the sides of the photometric ring.

The measures of the intensity of the light of the Welsbach lamp in terms of the standard candle were made by a friend. He made sixteen measures with my Rotating-Disk Photometer and sixteen with the Bunsen Photometer.

The mean of the series of measures made with the Rotating-Disk Photometer differed from the mean of the departure of the maximum and minimum measures from the mean by 1·49 per cent of the mean intensity of the light of the Welsbach lamp.

The mean of the series of measures made with the Bunsen Photometer differed from the mean of the departure of the maximum and minimum measures from the mean by 5·22 per cent of the mean intensity of the light of the Welsbach lamp.

Hoboken, N. J., April 15, 1893.

ART. II.—*Kehoeite, a new Phosphate from Galena, Lawrence Co., S. D.;* by WM. P. HEADDEN.

ABOUT three years ago I received a number of minerals, mostly from the Merritt mine located at Galena, S. D., among which was the material described in this note. The mineral forms seams and bunches in the ore at one point in the mine. The ore is an argentiferous galena carrying zinc blende and iron pyrites. Goslarite occurs at other points in the mine but was not found in the immediate vicinity of this occurrence. The nearest point at which the goslarite was observed was some 500 feet distant.

The material is white, amorphous and insoluble in water, but it yields a small amount of zincous oxide and phosphoric acid to concentrated hydric acetate upon continued boiling. Ammonic

hydrate extracts rather more zinc than the hydric acetate but does not dissolve it to any great extent. Concentrated potassic hydrate as well as the dilute hydric salts, i. e. HCl. HNO_3 and H_2SO_4 dissolve it readily and completely. The washed mineral forms an impalpable powder with a specific gravity of 2·34 at 15°; it is infusible, and in the closed tube yields an abundance of water. With soda on charcoal it gives an incrustation of zinc oxide, obtained with some difficulty—and reacts for alumina, when moistened with cobalt solution. Borax and phosphorus salt dissolve it readily; the beads are slightly yellow while hot and colorless when cold. The saturated beads become opaque upon flaming.

The strongly ignited mineral is not completely soluble in HCl, HNO_3 or in aqua regia; the residue insoluble in these acids contains alumina and zinc, but no phosphoric acid or only traces of it. The air-dried material loses when dried at 105–110°, 14·2 per cent and loses but 3·34 per cent additional between 115–120°. It required continued heating over a Kellogg burner to expel the last portion of water. The washed and air-dried material had the following composition:

	I.	II.	III.
Insoluble	1·76	1·78	1·74
H_2O	31·06	31·04	30·92
P_2O_5	26·76	26·74	26·78
SO_3	·50	·54	----
ZnO	11·64	11·54	11·58
CaO	2·70	2·90	----
Al_2O_3	24·84	25·62	
Fe_2O_3	·78		
MgO	·08	----	
Cl	trace	trace	
	100·02	100·16	

Analysis No. I gives after deducting the insoluble—

H_2O	31·60 = 0·2808	·2808	8·91	9	27
P_2O_5	27·13	0·1529	·1560	4·96	5	15
SO_3	·51	0·0031				
ZnO	11·74	0·0232	·0314	1	1	3
CaO	2·75	0·0079				
MgO	·08	0·0003				
Al_2O_3	25·29	0·1178	·1202	3·83	4	12
Fe_2O_3	·79	0·0024				
	99·94					

The oxygen ratios correspond to $3RO + 4R_2O_3 + 3P_2O_5 + 27H_2O$, or $R_3P_2O_8 + 2Al_2P_2O_8 + 2Al_2(OH)_6 + 21H_2O$ in which

$R = Zn_{\frac{3}{4}} + Ca_{\frac{1}{4}}$. The small amount of SO_3 present and the deportment of the material toward concentrated hydric acetate indicate the absence of any significant quantity of basic sulphate or hydrated oxide of zinc. The analyses show an excess of basic oxides over the quantity required by the P_2O_5 present in order to form neutral salts, and the fact that igniting the material rendered a part of it insoluble may be interpreted in the same sense, especially as the insoluble portion is quite free from phosphoric acid and consists largely of alumina. On the other hand the presence of zinc and phosphoric acid in the hydric acetate solution is suggestive of the presence of a zincous phosphate.

As a control on the water-determination, a portion of the unwashed mineral which had been kept for upwards of three years in a stoppered but unsealed bottle, and then exposed to the atmosphere of a warm room for three days, was ignited and showed a loss of 31·48 per cent. I could not detect any CO_2 in the mineral.

The formula suggested, when R=Zn, requires: P_2O_5 27·25, Al_2O_3 26·10 . ZnO 15·67 and H_2O 31·09.

The relationship of this mineral is not evident. If, however, the analysis made by Hermann on material from Richmond, Mass., and given on p. 178, Dana's System of Min., 5th ed., is correct, then there is an aluminic phosphate having the formula $Al_2P_2O_8+9H_2O$ and the material presented in this note may be a molecular combination of the following character: $2(Al_2P_2O_8+9H_2O)+2Al_2(OH)_6+(Zn_3P_2O_8+3H_2O)$.

I propose Kehoeite as the name of this mineral, after Mr. Henry Kehoe, to whom I am indebted for the material and who was the first to observe its occurrence.

Note on Jarosite.—This mineral is found as a coating in and sometimes partly filling larger cavities in the auriferous quartzite which is the chief ore obtained in the Buxton mine, Lawrence Co., S. D. It also occurs in the smaller cavities of the rock and in distinct crystals associated with small quartz crystals which cover old fracture-planes in the rock. The jarosite where it is free from limonite has a golden yellow color and the mass is composed of scales which under the microscope appear as six-sided plates. The largest crystals observed were about 2^{mm} in breadth and have a light brown color; their form could be recognized with the aid of a good magnifier as a combination of a rhombohedron and the basal plane.

The purest material that I could select gave:

Quartz	6·10	Quartz deducted.		O.	
SO_3	28·46	30·29	= ·1817	·1904	12
As_2O_5	2·36	2·51	·0087		
Fe_2O_3	46·27	49·28	·1478	·1478	9·35
CaO	·39	·42	·0012		
Na_2O	4·35	4·62	·0119	·0158	1
K_2O	1·47	1·57	·0027		
H_2O	10·55	11·24	·0999	·0999	6·3
	99·95	99·93			

The excess in O ratios for the iron and water is to be attributed to the presence of some ferric hydrate and the O ratios for the sample is 1 : 9 : 12 : 6.

State School of Mines, Rapid City, S. D.

Art. III.—*On the Ammonium-Lead Halides;* by H. L. Wells and W. R. Johnston.

It is a well known fact that the ammonium double halides, like other ammonium salts, are usually analogous to those of the alkali-metals, especially to those of potassium. For example, in connection with an investigation of the cæsium-mercuric halides, made by one of us,* it was noticeable that cæsium compounds were prepared, corresponding to all of the four types of ammonium-mercuric halides that had been previously described.

A study of the cæsium-lead and potassium-lead halides has recently been made in this laboratory,† and, in view of the fact that the existence of four very simple types of double salts was established by that investigation, it seemed desirable to reinvestigate the ammonium-lead halides, since a considerable number of these with very complicated formulæ had been described. These peculiar ammonium-lead halides have formed the most noticeable exception to the similarity of the alkali-metal and ammonium salts, and it seems probable that it was chiefly on account of these that Remsen has remarked :‡ "The position of the double halides containing ammonium is certainly exceptional. They seem to be governed by some law of their own."

All of the extremely complicated ammonium-lead salts have been described by André.§

The list of his alleged compounds is as follows:

* This Journal, xliv, 221. † This Journal, xlv, 121.
‡ Am. Chem. Jour., xi, 296.
§ Compt. Rend., xcvi, 435 and 1502; Bull. Soc. Chim., [2], xl, 14.

$PbCl_2.18NH_4Cl.4H_2O$
$PbCl_2.10NH_4Cl.H_2O$
$2PbCl_2.18NH_4Cl.3H_2O$
$PbCl_2.6NH_4Cl.H_2O$
$4PbCl_2.22NH_4Cl.7H_2O$
$4PbCl_2.18NH_4Cl.5H_2O$
$4PbCl_2.2NH_4Cl.6H_2O$

$2PbBr_2.14NH_4Br.3H_2O$
$PbBr_2.6NH_4Br.H_2O$
$7PbBr_2.12NH_4Br.7H_2O$
$3PbBr_2.2NH_4Br.H_2O$

From André's original articles, it appeared that he made no mention of having ever prepared any of his remarkable products more than once, and it seems probable that whenever he obtained a crop of crystals or a precipitate he described it as a new compound, without regarding the number of different substances that it might contain. André operated in two ways. A part of his salts were made by dissolving a lead halide in a hot solution of the corresponding ammonium halide and cooling, while the rest were made by dissolving lead monoxide in boiling solutions of ammonium chloride or bromide. From the products made by the last method he obtained lead oxychlorides or oxybromides by heating them with water in sealed tubes. This peculiarity of these products caused him to remark that all the chlorides made in this way seemed to contain some oxychloride. This is the only evidence of any suspicion on his part that he was obtaining mixtures. In a number of instances André describes his products as "crystalline precipitates," "brilliant plates with pearly lustre," "crystallized bodies" etc, so that it would seem that they should have been pure, but after having repeated his experiments, following his methods as closely as his descriptions permitted, with many variations and repetitions, *we are convinced that not one of the salts described by André exists.*

Our work has resulted in the preparation of the following series of salts:

Type 2 : 1	Type 1 : 1	Type 1 : 2
----------	$3NH_4PbCl_3.H_2O$	$NH_4Pb_2Cl_5$
$(NH_4)_2PbBr_4.H_2O$	----------	$NH_4Pb_2Br_5$
----------	$NH_4PbI_3.2H_2O$	----------

For comparison, the potassium series, already referred to, is given:

Type 2 : 1	Type 1 : 1	Type 1 : 2
----------	$3KPbCl_3.H_2O$	KPb_2Cl_5
$K_2PbBr_4.H_2O$	$3KPbBr_3.H_2O$	KPb_2Br_5
	$KPbBr_3.H_2O$	
----------	$KPbI_3.2H_2O$	----------

It is to be noticed that the two series correspond exactly, except that no ammonium-lead bromide of the 1 : 1 type was

obtained. These results show that the ammonium-lead halides are entirely analogous to the potassium salts, and that there is no indication that they are governed by a law of their own.

Returning to the mixtures described as compounds by André, it should be noticed that he came near finding the correct formulæ for three salts. His formula $4PbCl_2.2NH_4Cl.6H_2O$ would be correct if the water were omitted. He should have found two more molecules of NH_4Br in the formula $7PbBr_2.12NH_4Br.7H_2O$ in order to have the salt $(NH_4)_2PbBr_4.H_2O$, and his formula $3PbBr_2.2NH_4Br.H_2O$, in comparison with the errors involved in his more complicated mixtures, is rather near $NH_4Pb_2Br_5$.

Such work as André's is liable to hinder the development of correct chemical theories. A case has been mentioned above where it is probable that his results have been an important factor in causing the ammonium double halides to be looked upon as a class of bodies distinct from the alkali-metal compounds, and it may be mentioned that Carnegie* has used André's formula $PbBr_2.6NH_4Br$ in support of a theory on double halides, although, as must be added, he considers André's more complicated formulæ as inconsistent with his ideas.

We have investigated the ammonium-lead halides by methods which are entirely like those used for the potassium salts, and, in addition, numerous experiments have been made in order to investigate André's methods of preparation. The analytical methods used have been simple. Ammonium was determined by distillation with potash solution and alkalimetry. Lead was determined by treating the substance in a platinum crucible with sulphuric acid, evaporating, igniting and weighing lead sulphate. To determine a halogen, the substance was treated with hot water and an excess of silver nitrate was added; after sufficient digestion, nitric acid was added, and when the precipitate had settled properly it was collected and weighed on a Gooch filter. Water was determined by the loss at 100°, or sometimes at a somewhat higher temperature.

1 : 1 Ammonium-Lead Chloride, $3NH_4PbCl_3.H_2O$:—This is formed by dissolving lead chloride in hot concentrated solutions of ammonium chloride and cooling. Sample A was made by dissolving 25^g of $PbCl_2$ in 700^{cc} of an ammonium chloride solution which was more than saturated when cold. The double salt was deposited in the form of colorless, transparent, prismatic crystals while the solution was still somewhat warm. Some of the crystals were removed from the warm solution, quickly pressed between smooth filter-papers and air-dried for analysis. On cooling the solution, ammonium chloride crystallized upon the double salt. Sample B was obtained by dissolv-

* Am. Chem. Jour., xv, 11.

ing 5^g of PbO in 200^{cc} of a boiling solution of NH_4Cl which was nearly cold-saturated. The last method was suggested by André's experiments.

	A	B	Calculated for $3NH_4PbCl_3.H_2O$
Ammonium	5·22– 5·45	.....	5·33
Lead	61·12–60·60	61·84–61·88	61·31
Chlorine	31·78–31·79	31·64	31·56
Water.....	1·78	.....	1·78

The water in A was determined by heating at about 120° for one hour. The limits of the conditions under which this salt is formed are narrow, for, on slightly diluting the solutions which have given it, the following compound is produced.

1:2 Ammonium-Lead Chloride, $NH_4Pb_2Cl_5$:—This salt is produced under wide limits of conditions. It forms colorless, short, transparent prisms which are usually doubly terminated and are apparently orthorhombic in form. The crystals retain their luster on drying and are anhydrous.

Four crops were made under the following conditions:

	NH_4Cl	$PbCl_2$	Volume.
A	100 g.	30 g.	1000^{cc}
B	100	20	1000
C	200	15	550
D	200	60	700

These crops gave the following analyses:

	Ammonium.	Lead.	Chlorine.
A	2·36–2·67	67·38–67·36	29·08–29·14
B	.....	66·26–67·56	.....
C	.....	66·94–66·76	29·16–29·24
D	.....	68·00–67 28	.....
Calculated for $NH_4Pb_2Cl_5$	2·95	67·93	29·12

Another double chloride was observed, the composition of which was not determined. It will be referred to beyond, under the discussion of André's products.

2:1 Ammonium-Lead Bromide, $(NH_4)_2PbBr_4.H_2O$:—This salt is easily prepared by dissolving lead bromide in concentrated solutions of ammonium bromide. Its formation was also observed when lead oxide was dissolved in ammonium bromide by boiling. It forms beautiful radiating groups of highly refracting, slender prisms. Three crops were made as follows:

	NH_4Br	$PbBr_2$	Volume.
A	200 g.	50 g.	380^{cc}
B	?	25	260
C	200	50	380

The analyses were as follows:

	Ammonium.	Lead.	Bromine.	Water.
A	6·01–5·86	37·12–36·84	55·06–55·10	2·60
B	.....	37·06–36·94	54·94	....
C	.....	37·26	.....	....
Calculated for $(NH_4)_2PbBr_4.H_2O$	6·17	35·63	55·08	3·10

1 : 2 Ammonium-Lead Bromide, $NH_4Pb_2Br_5$:—On slightly diluting solutions from which the preceding salt would be deposited, this salt is obtained. Repeated trials were made to obtain a 1 : 1 salt intermediate between the two, but these were without success. The salt forms square plates, often several millimeters in diameter. The crystals darken somewhat on exposure to light, but they do not lose their luster on drying, and are evidently originally anhydrous. The compound is formed under rather wide limits of conditions. A single sample was analyzed.

	Found.	Calculated for $NH_4Pb_2Br_5$
Ammonium.....	2·17– 2·17	2·16
Lead	49·26–49·12	49·76
Bromine	48·28–48·22	48·08

1 : 1 Ammonium-Lead Iodide, $NH_4PbI_3.2H_2O$:—This was the only double iodide obtained, although a thorough search was made for other salts. It forms hair-like crystals of a pale yellow color. Sample A was made by disssolving 100^g of NH_4I and 10^g of PbI_2 in sufficient hot water to make a volume of 108^{cc}, and cooling. Sample B was obtained by slightly diluting the solution which gave A. It was noticed that where lead iodide was deposited from a moderately concentrated hot solution of ammonium iodide, the lead iodide disappeared on cooling and in its place was formed a compact, silky mass of crystals. Sample C was such a crop as just described, which was carefully separated from the usual form of the double salt which formed above in the solution.

	A	B	C	Calculated for $NH_4PbI_3.2H_2O$
Ammonium .	2·40– 2·25	2·97– 2·97	....	2·80
Lead	31·08–31·46	31·36–31·20	31·76	32·24
Iodine	59·76–59·70	59·85–59·75	62·45	59·36
Water.....	5·60	5·65	....	5·60

On André's Products.

André prepared some of his most complicated products, such as $2PbCl_2.18NH_4Cl.3H_2O$ and $4PbCl_2.22NH_4Cl.7H_2O$, by dis-

solving lead chloride in ammonium chloride solutions and by the use of the corresponding bromides. On repeating his experiments with the bromides, we have not observed anything which did not correspond to the salts which we have described, or to mixtures of these with ammonium bromide. He describes his product $4PbCl_2.22NH_4Cl.7H_2O$ as an abundant precipitate of very brilliant plates with a pearly luster. We have often observed this beautiful precipitate, but, after many attempts, we have been unable to determine its composition with certainty. It apparently forms only in warm solutions which are almost saturated with ammonium chloride. The prismatic salt $NH_4Pb_2Cl_5$ is usually deposited just before the plates begin to form, and it often forms with them. Large amounts of ammonium chloride often crystallized out when attempts were made to separate the precipitate from the mother-liquor. This happened often even when the solution with the suspended precipitate was poured upon a large mass of filter-paper, so as to soak up the liquid as quickly as possible. Such a crop, which was granular and showed little evidence of being composed of plates, gave 30·50 per cent of lead. By collecting the precipitates, in the manner just described, at an earlier period in the process of their formation, we succeeded in obtaining crops that were apparently pure, but the plates were so exceedingly thin and small, and the mother-liquor was so concentrated, that we had little confidence in the purity of these products. Two such crops gave 51·13 and 53·69 per cent of lead. The formula $(NH_4)_2PbCl_4$ requires 53·77, and it is possible that this may be the true formula for the substance. It is certain that these two products were practically free from the prismatic salt $NH_4Pb_2Cl_5$, so that it can be positively stated that the ratio of ammonium to lead cannot be greater than 2 : 1 in this compound. André's formula is, therefore, very far from correct. He must have analyzed a mixture of the plates with ammonium chloride. We have found all such mixtures to be anhydrous after being dried in the air for a short time, hence the water in André's formula is remarkable.

A number of attempts were made to obtain the compound in a purer state by warming the solutions and by diluting them slightly, after the precipitates had formed, but these operations left the products open to suspicion, since it was found that further dilution completely decomposed the plates. Several crops, made in this way, gave 59·01, 57·64, 53·69 and 57·80 per cent of lead, which is an insufficient amount for the 1 : 1 anhydrous salt, requiring 62·4. This may be its composition, but it is possible also that it is a dimorphous form of $NH_4Pb_2Cl_5$, for the plates, in being square with diagonal markings, resemble the salt KPb_2Br_5 and other bromides of this type. The unde-

termined double chloride can be readily prepared by dissolving 160^g of ammonium chloride and 25^g of lead chloride in sufficient boiling water to make a volume of 400^{cc}, and allowing the solution to cool slowly. The compound often forms in such abundance as to completely fill the solution with a loose mass of the very thin plates.

André's other method of preparing his products was by dissolving lead monoxide in ammonium chloride and bromide solutions. He describes only one complicated bromide, $PbBr_2.6NH_4Br.H_2O$, made in this way. We have made a number of experiments with ammonium bromide and lead oxide without obtaining anything but our own salts and mixtures. Since a number of his chlorides were made by dissolving lead oxide in ammonium chloride solutions, we have made a very careful study of the products obtained by this operation. André sometimes indicates the length of time of boiling the ammonium chloride solution with lead oxide, but is uncertain how rapidly he boiled his solutions. We have therefore made numerous experiments with wide variations in the amount of ammonia boiled off. Among the various products that we obtained, including the salts that we have described, we frequently noticed a substance that appeared to be new. It was deposited after the solutions had become cold or nearly so, forming brilliant crystals, apparently nearly cubic in form, but so much rounded as to have no distinct faces. These crystals were often 1 or 2^{mm} in diameter. They formed upon the bottom and sides of the beaker, adhering firmly to the glass, and their quantity was sometimes such that the walls of the vessel were thickly studded with them. This product evidently corresponded with one of André's, for he says of "$PbCl_2.18NH_4Cl.4H_2O$" that it is a very hard crystalline deposit adhering to the glass. We encountered considerable difficulties in obtaining the substance in a pure condition, for it was inclined to deposit upon other things that had previously formed, and it adhered to them as well as to the glass. The first crop analyzed (No. 1) was evidently not pure. Two other crops (2 and 3) appeared better, but still not quite pure. At least, by decanting a solution just before these crystals began to form, we obtained a crop (No. 4), that seemed entirely satisfactory. The following analyses of the four crops were made:

	Ammonium.	Lead.	Chlorine.
No. 1, ...	28·28	13·44	58·05 = 99·77
No. 2, ...	....	6·51	....
No. 3, ...	....	6·74	....
No. 4, ...	....	1·08	....

The crystals of the last product had exactly the same appearance as the others. It is evident that lead is not an essential

constituent of the substance, and that the substance is ammonium chloride crystallized in an unusual form. Analysis No. 1, corresponds to $PbCl_2.24NH_4Cl$. This is not far from André's formula and it shows what he probably analyzed. It is to be noticed that, while our impure ammonium chloride was practically anhydrous, André gives a considerable amount of water in his formula. It seems probable that he did not properly dry his products before analyzing them, and, moreover, he evidently determined water from the deficiencies in his analyses. There is more or less water in every one of his formulæ.

Since it was evident that André's operation of boiling ammonium chloride solutions with lead oxide could be imitated, with possibilities for greater variations, by adding ammonia to solutions of lead chloride in ammonium chloride, we have carried out a series of experiments on that plan. No indications of the existence of any of André's complicated compounds were obtained in this way, but, besides the form of ammonium chloride that adheres to the glass, a peculiar modification of it in the form of large, transparent pointed crystals with no distinct faces was observed. A sample of these contained 3·23 per cent of lead. When much ammonia was used in these experiments, an oxychloride of lead was obtained. A pure product of this was prepared by saturating a cold-saturated solution of ammonium chloride with lead chloride while boiling, then adding an equal volume of the cold-saturated ammonium chloride solution and finally adding a large excess of ammonia. A precipitate was formed and re-dissolved by the ammonia. The oxychloride was deposited on cooling, in the form of small, blade-like, transparent crystals. Analysis showed that it was the compound PbClOH.

	Found.	Calculated for PbClOH.
Lead	79·17	79·77
Chlorine	14·06	13·68
Oxygen	[2·72]	3·08
Water	4·05	3·47

This compound has long been well known, having been used as a white pigment. It is worthy of remark that André redescribed this body correctly in one of his papers that has already been referred to.* He made it by heating a small quantity of "$PbCl_2.6NH_4Cl.H_2O$" with water in a sealed tube. It is evident that such a product could not have been produced if the chlorides had not contained some basic substance.

* Bull. Soc. Chim., II, xl, 15, (1883).

Experiments with Ammonium Choride and Lead Iodide.

Poggiale* and Völkel† have each described a mixed double halide of ammonium and lead, neither of which agrees with the types of unmixed halides which we have described in this article. Poggiale's formula is $PbI_2.4NH_4Cl.2H_2O$, while Völkel's is $PbI_2.3NH_4Cl$. It is evident that the two investigators obtained the same compound, for both made their products in essentially the same way, and both describe them as occurring in the form of silky needles. We have repeated the experiment of dissolving lead iodide in ammonium chloride solutions and have readily obtained the silky crystals. The product resembles exactly the salt $NH_4PbI_3.2H_2O$, except that it is considerably paler in color than the latter. An analysis of a pure product, carefully dried by pressing with paper, showed that the formulæ of both Poggiale and Völkel are incorrect, and that their products must have been contaminated with ammonium chloride. The salt corresponds in type to our double iodide. It loses one molecule of water on exposure to the air for two or three days, becoming much darker in color; the second molecule of water goes off at 100°.

	Found.	Calculated for $NH_4Cl.PbI_2.2H_2O$.
Ammonium	3·33	3·27
Lead	34·83–34·68	37·60
Chlorine	5·11– 5·10	6·45
Iodine	51·08–50·94	46·14
Water	5·35	6·54

The analysis indicates that the lead iodide and ammonium chloride do not combine quite unchanged, and that the formula $NH_4Pb(Cl,I)_3.2H_2O$ possibly expresses the composition of the product better than the one given above. In the course of our experiments with ammonium chloride and lead iodide, we obtained a crop of crystals which showed an almost complete replacement of the iodine by chlorine. The salt was a 1 : 2 compound, a type which apparently does not exist among the double iodides of lead. It gave the following analysis:

	Found.	Calculated for $NH_4Pb_2Cl_5$
Ammonium	-----	2·95
Lead	66·82	67·93
Chlorine	28·76	29·12
Iodine	1·44	

The view that certain mixed lead double halides are to be considered as variable mixtures of two isomorphous, unmixed

* Compt. Rend., xx, 1180. † Pogg. Ann., lxii, 252.

double halides was arrived at by Wells and Wheeler* from experiments with cæsium chloride and lead bromide. Herty† has more recently arrived at the same conclusion from his investigation of the mixed double bromide and iodide of potassium and lead. It is not safe to conclude, however, because definite mixed double halides do not occur in some cases, that they are never formed. It is certain that there is a tendency toward the formation of such definite compounds in many cases. For example, it is to be noticed that in the above analysis of $NH_4Cl.PbI_2.2H_2O$ there is only a slight variation from the composition required by the formula, while, from a solution of the same ingredients, another type of salt was deposited which was almost free from iodine. The compound $Cs_2HgCl_2I_2$,‡ described by one of us, is evidently a definite mixed double halide which is not intermediate in its properties between the corresponding chloride and iodide, and which has a constant composition. A number of other cæsium-mercuric halides were described, which approached a constant composition when made under varying conditions.

Sheffield Scientific School, March, 1893.

ART. IV.—*On the Rubidium-Lead Halides, and a Summary of the Double Halides of Lead;* by H. L. WELLS.

THE cæsium-lead and potassium-lead halides have already been studied in this laboratory, and an account of the ammonium compounds is given in the preceding article. It has therefore seemed desirable to make an investigation of the rubidium salts in order to make the work more complete.

2 : 1 Rubidium-Lead Chloride, $2Rb_2PbCl_4.H_2O$:—This was formed by dissolving lead chloride in a solution of rubidium chloride which was so concentrated as to be almost saturated when cold. It forms colorless, transparent, slender, flat prisms which retain their luster on exposure to the air. Two separate crops were analyzed.

	Found.		Calculated for $2Rb_2PbCl_4.H_2O$
Rubidium	29·63	29·85	32·39
Lead	41·41	41·75	39·20
Chlorine	26·73	26·84	26·90
Water	2·29	2·01	1·51
	100·06	100·45	100·00

* This Journal, lxv, 129. † Am. Chem. Jour., xv, 81.
‡ This Journal, xliv, 232.

The amount of water in the salt seems somewhat uncertain, but, since there was no evidence of loss of water by efflorescence and since the salt was simply air-dried without being pulverized, the above formula is preferred to $Rb_2PbCl_4.H_2O$ which requires 2·99 per cent of water. The water was determined by heating to about 200°; at 100° the salt lost only about one quarter of its water in twelve hours.

1:2 Rubidium-Lead Chloride, $RbPb_2Cl_5$:—This compound forms small, prismatic crystals which are usually grouped side by side in nearly parallel position. It is produced from solutions which are more dilute than those from which the preceding salt is prepared, and it is formed under rather wide limits of conditions. Two separate crops gave the following analyses:

	Found.		Calculated for $RbPb_2Cl_5$
Rubidium	13·09	12·68	12·63
Lead	60·57	61·05	61·15
Chlorine	26·19	26·29	26·22
	99·85	100·02	100·00

2:1 Rubidium-Lead Bromide, $2Rb_2PbBr_4.H_2O$:—This salt resembles the corresponding chloride, both in its formation and appearance. Two crops gave the following analyses:

	Found.		Calculated for $2Rb_2PbBr_4.H_2O$
Rubidium	23·17	22·73	24·19
Lead	30·29	30·81	29·29
Chlorine	----	45·04	45·26
Water	1·55	1·51	1·27
		100·09	100·00

1:2 Rubidium-Lead Bromide, $RbPb_2Br_5$:—This forms square plates. It is readily prepared since it is formed under considerable variations of conditions.

	Found.	Calculated for $RbPb_2Br_5$
Rubidium	9·81	9·50
Lead	45·74	46·03
Bromine	44·62	44·47
	100·17	100·00

1:1 Rubidium-Lead Iodide, $RbPbI_3.2H_2O$:—This is the only double iodide that could be produced under widely varying conditions. It forms very slender, hair-like prisms of a

pale yellow color. It rapidly loses its water when exposed to the air, undergoing a remarkable change of color. The pale yellow compound quickly assumes an orange color, then the color becomes almost like that of the original salt. It is evident that the salt, which contains two molecules of water, loses a part of this, probably one molecule, with change of color to orange; then the remainder of the water is lost with another change of color. It is interesting to notice, in this connection, that the salt $NH_4PbClI_2.2H_2O$ undergoes a similar change of color, as far as the first step is concerned, on losing one molecule of water when it is exposed to the air, but this salt does not lose its second molecule at ordinary temperatures. A sample of the rubidium-lead iodide was rapidly pressed on paper until some of the particles began to show a change of color to orange. Water was determined in this sample from the loss at 100°.

	Found.	Calculated for $RbPbI_3.2H_2O$
Water	6·09	5·07

An air-dry sample gave the following analysis:

	Found.	Calculated.
Rubidium	13·29	12·70
Lead	28·95	30·73
Iodine	56·80	56·57
	99·04	100·00

Summary.

The following table gives a list of the lead double halides which have been prepared in this laboratory. All of them were new compounds except $KPbBr_3.H_2O$ and $KPbI_3.2H_2O$, these having been previously described by Remsen and Herty.

4:1	*2:1*	*1:1*	*1:2*
Cs_4PbCl_6	----	$CsPbCl_3$	$CsPb_2Cl_5$
Cs_4PbBr_6	----	$CsPbBr_3$	$CsPb_2Br_5$
----	----	$CsPbI_3$	----
----	$2Rb_2PbCl_4.H_2O$	----	$RbPb_2Cl_5$
----	$2Rb_2PbBr_4.H_2O$	----	$RbPb_2Br_5$
----	----	$RbPbI_3.2H_2O$	----
----	----	$3KPbCl_3.H_2O$	KPb_2Cl_5
----	$K_2PbBr_4.H_2O$	$3KPbBr_3.H_2O$	KPb_2Br_5
		$KPbBr_3.H_2O$	
----	----	$KPbI_3.2H_2O$	----

----	----	$3NH_4PbCl_3.H_2O$	$NH_4Pb_2Cl_5$
----	$(NH_4)_2PbBr_4.H_2O$	----	$NH_4Pb_2Br_5$
----	----	$NH_4PbI_3.2H_2O$	----
----	----	$NH_4PbClI_2.2H_2O$	----

An inspection of the table shows that the cæsium salts differ from the others in including the 4 : 1 type and in being without any 2 : 1 salts. It is quite probable that we have not succeeded in preparing all the salts that are possible, but it seems certain that the 4 : 1 rubidium, potassium and ammonium salts cannot be made on account of the comparative insolubility of the simple halides. The cæsium salts also differ from the others in being all anhydrous. The hydrous rubidium salts have less water or lose it more readily than the potassium compounds. $KPbI_3.2H_2O$ is stable in the air, but $RbPbI_3.2H_2O$ loses its water readily. There is evidently a gradation, in affinity for water, from the cæsium to the potassium compounds. A gradation in water, from the chloride to the iodide, apparently exists in the potassium and ammonium compounds of the 1 : 1 type. That such gradations in water exist among the double halides, increasing with the atomic weight of the halogens and decreasing with the atomic weight of the alkali metals, has already been observed by Remsen.*

The simplicity of the ratios in the four types of double halides of lead is noticeable. The 4 : 1 type, according to Werner's remarkable theory,† may be considered as the ideal type of a double halide of an alkali-metal and a bivalent metal, and as the limit beyond which the ratios of alkali-metal to lead cannot go. The type is represented, as Werner mentions, by numerous double cyanides of bivalent metals, such as $K_4Fe(CN)_6$ and by other salts, such as K_4CdCl_6.

The number of 2 : 1 lead salts that we have prepared is rather small, but this is a very common type among the known double halides of the other bivalent metals.

The number of 1 : 1 lead salts is the largest of all. It is remarkable that all the double iodides belong to this type. This is also a well known type of bivalent metal double halides. It is noticeable that the salt $CsPbBr_3$ is dimorphous, while three mercuric salts of the same type,‡ $CsHgCl_3$, $CsHgBr_3$ and $CsHgClBr_2$ are also dimorphous.

The 1 : 2 salts are all anhydrous, and a chloride and bromide were prepared with each of the alkali-metals and with ammonium. They are formed under wide limits of conditions and are therefore very easily prepared. It is noticeable that the rubidium, potassium and ammonium chlorides of this type

* Am. Chem. Jour., xiv, 88. † Zeitschr. anorgan. Chem., iii, 281.
‡ This Journal, xliv, 222.

all crystallize in prisms, while all the bromides and the chloride containing cæsium crystallize in plates. A number of other double halides of this types are known, especially among the mercuric compounds. Herty has evidently prepared a potassium-lead double halide of the 1 : 2 type containing bromine and iodine, although he interprets his results in an entirely different way. In a recent article* he describes some tabular crystals of an olive-green color which he has selected and analyzed with evident care and skill. He gives the following analyses of three separate products:

	Pb	I	Br	K	
p. 95, D	44·89	17·61	32·59	4·56	= 99·65
p. 95, E	45·42	14·94	34·72	4·50	= 99·58
p. 104,	43·87	22·20	29·03	4·43	= 99·53

The following ratios may be derived from the above analyses:

	Pb. :	I+Br :	K
p. 95, D	2·	5·01	1·07
p. 95, E	2·	5·15	1·08
p. 104,	2·	5·08	1·08

The ratio required for the formula $KPb_2(Br,I)_5$ is Pb : I+Br : K = 2 : 5 : 1 and the agreement is so close that there can be no doubt that this is the formula. Although no pure iodide of this type has been produced, it is interesting to notice that Herty's compound shows that the potassium salt is capable of existence when mixed with a relatively large amount of the bromide.

Sheffield Scientific School, March, 1893.

ART. V.—*The Galveston Deep Well;* by E. T. DUMBLE and G. D. HARRIS.

The Section.—E. T. Dumble.

THE City of Galveston, Texas, desiring to secure fresh water on the island, if possible, rather than go to the mainland for it, and having failed to do so at moderate depths, decided to sink a well to the depth of three thousand feet unless suitable water was found before going so far. I therefore detailed Mr. J. A. Singley to watch the boring and to secure all the information possible from it.

Work began in April, 1891, and continued with various interruptions and delays until August, 1892. The method used

*Am. Chem. Jour., xv, pp. 94, 95, 97–99, 103, 104 (Feb. 1893)

—that of revolving and jetting by Chapman Bros., Aurora, Illinois—is fully described by Mr. Byrnes, the contractor, in the Engineering News, August 11th, 1892.

The piping of the finished well is as follows:

15 in.	868 feet	868 feet.
12 in.	629 feet	1499 feet.
9 in.	866 feet	2363 feet.
8 in.	75 feet	2438 feet.
7 in.	162 feet	2600 feet.
5 in.	470 feet	3070 feet.

Many hundreds of samples were taken at the mouth of the well throughout the work and those necessary to show the character and variations of the several beds that were penetrated together with all the fossils collected were carefully preserved and are now in the collections of the Geological Survey of Texas.

Mr. Singley's section, made after a critical study of the specimens taken by him from the well, differs a little from the log of the well-borers as given by Mr. Byrnes in the article referred to and by Prof. Hill in this Journal for November, 1892.* Therefore, although a part of it has already been published,† the entire section is given in a condensed form.

Nos.		T'kn's.	D'pth
1.	Buffy gray sand	46–	46
2– 3.	Clay brown and mottled, calcareous concretions, etc.	54–	100
4– 5.	Sandy clay underlaid by fine gray sand	67–	167
6–10.	Alternations of clays and sands containing shells and fragments of lignite	291–	458
11–15.	Clayey sands and sandy clays with some mica.	154–	612
16–18.	Sandy clays with shell fragments	94–	706
19–21.	Sand and clayey sand	121–	827
22.	Coarse silvery-gray sand—water bearing	55–	882
23–25.	Sandy clay with lignite and few shells	29–	911
26.	Indurated coarse gray quartz sand	3–	914
27–28.	Sand and clayey sand, micaceous	118–	1032
29.	Sandy clay	228–	1260
30.	Coarse gray quartz sand—water bearing	28–	1288
31–32.	Clay and sandy clay	42–	1330
33.	Coarse gray quartz sand—water bearing	10–	1340
34–36.	Clays	44–	1384
37.	Coarse gray sand	9–	1393
38–40.	Sandy clays, variously colored	55–	1448
41–43.	Sand, sandy clay and clay	45–	1493

* The deep Artesian Boring at Galveston, Texas, p. 426.

† Geological Survey of Texas, Second Report of Progress, Artesian Water by J. A. Singley, p. 78.

Nos.		T'kn's.	D'pth
44.	Greenish gray sand, micaceous—water bearing	18–1511	
45–47.	Laminated clays with pebbles, etc., and clayey sand 243	243–1754	
48.	Cream colored, gritty, calcareous conglomerate	4–1758	
49–53.	Alternations of sand and sandy clays	118–1876	
54–57.	Ditto with lignite, calcareous concretions, etc.	184–2060	
58–59.	Sandy clay and clayey sand	37–2097	
60–61.	Laminated clay, micaceous sand	56–2153	
62–63.	Greenish clay, indurated gray sand	67–2220	
64.	Dark clay with lignite, fruits, corals, fish remains, terrestrial and fluviatile shells	29–2249	
65–70.	Clayey sands, shell conglomerate and sand	96–2345	
71.	Coarse gray sand—water bearing	32–2377	
72–75.	Clays with pyrites, lignite, fish remains and shells	55–2432	
76.	Buff sand—water bearing	11–2443	
77.	Mottled clay, lignite, fish remains and shells	8–2451	
78.	Lignite	2–2453	
79.	Clay, vegetable and animal remains	23–2476	
80–83.	Sand, micaceous in places—water bearing	76–2552	
84–87.	Alternations of clay and sand	85–2637	
88–89.	Sandy clay and clayey sand, fossiliferous	80–2717	
90.	Greenish clay, vegetable and animal remains	166–2883	
91.	Gray sand—water bearing	37–2920	
92–93.	Clayey sand and sandy clay	105–3025	
94.	Sandy clay, micaceous	22–3047	
95.	Coarse gray sand—water bearing	23–3070	

The water found in this lowest bed, although apparently less saline than that above it, was not suitable for general use.

While the method of boring employed was not the best for keeping the fossils of each stratum entirely separated from those below it, yet the anchoring of the different sizes of pipe at the depths given has acted as a partial safeguard against the commingling of the faunas of those different zones.

The fossils secured by the untiring watchfulness of Mr. Singley were numerous and varied, comprising many parts of plants, fruits, a pine cone, etc., fish remains and a large number of invertebrate forms. The shells were turned over to Mr. Gilbert D. Harris for examination, and his preliminary report is given herewith.

The results of the investigation add a most important chapter to our knowledge of the history of the formation of the Gulf coast, and furnish a section for reference and comparison which could have been obtained in no other way.

The thickness of the different members of the series as stated by Mr. Harris indicates either a greater dip than we have hitherto supposed to be the case in these deposits or else

a greater thickening toward the Gulf. Even at the depth attained the drill has not yet penetrated the sandstones, clays and browncoals of the Fayette Beds as shown at the typical localities in Fayette county, but is still in the sands and limy clays which overlie them.

Although the landward extension of these beds may come today somewhere in the area of the Gulf slope our investigations have, up to this time, failed to bring to light any localities which furnish marine invertebrates of an age later than the Claiborne. So far all the fossils found above that horizon are in fresh water deposits of Miocene, Pliocene, and Pleistocene age, and consist entirely of vertebrates.

The Paleontology.—Gilbert D. Harris.

The conclusions drawn from a study of the molluscan remains* obtained from this well, may be summarized as follows:

1. Of the 11 species obtained from samples numbered from 1 to 10 inclusive, all, except a new form of *Eriphyla*, are recent and well known. In all probability therefore the strata passed through between depths ranging from 0 to 450 feet must be referred to a post-Tertiary or Pleistocene epoch. The small *Eriphyla* will probably be found recent on the Gulf shore.

2. The fauna is so sparse between numbers 10 and 61 inclusive that it is unsafe to attempt to state just where in the upper Tertiary it should be placed. In fact beds included between depths 450 and 1500 may not be Tertiary at all but Pleistocene. The undescribed, and probably for the most part extinct species occurring from depths 1500 to 2150 feet show conclusively that these beds are Tertiary.

3. The fossils obtained from samples numberd 61 to 91 inclusive show that this part of the well section must be referred to the Miocene series. Moreover, it is quite evident that upon the whole the fauna represented is that of the upper rather than the lower Miocene. Out of about 72 species, 26 are still living on the Atlantic or Gulf coast of the United States, while 6 more survive only in the Pacific. Of the 36 new or doubtful forms probably the great majority are extinct, though it is unsafe to predict what will yet be found in the Gulf of Mexico. *Arca Carolinensis*, *Turritella subgrundifera* var. *Chione*, sp. nov. of west Florida Miocene, *Terebra*, n. sp. of west Florida Miocene and *Natica eminuloides* of the West Indian Miocene may be regarded as characteristic species, leaving no doubt, when taken in connection with the foregoing

* For a full account of the species obtained see Geol. Surv. Tex., 4th Annual Report.

facts that this portion of the well section belongs to the Miocene series, and in all probability to the upper part of the same.

The above conclusions may be stated diagrammatically as follows:

Sample Nos.	Depth in feet.	Geological horizons.
1–10	46– 458	Pleistocene.
10–44	458–1511	Doubtful.
44–61	1511–2153	Upper Tertiary.
61–91	2153–2920	Miocene (Upper)

Probably some of the strata between the depths of 458 and 2153 feet were deposited in Pliocene times, but not a trace of a species characterizing that series has been found.

ART. VI.—*On the Iodometric Determination of the Nitrates;* by HIPPOLYTE GRUENER.

[Contributions from the Kent Chemical Laboratory of Yale College—XXIV.]

DE KONINCK and Nihoul* describe a method for the iodometric determination of nitrates, in which the decomposition of the nitrates is effected by the action of gaseous hydrochloric acid, the gases evolved being passed into potassium iodide; but the method is a cumbersome one In a former paper† by Professor Gooch and myself a method was described according to which nitrates were decomposed successfully and easily by a solution of manganous chloride in hydrochloric acid, the products of decomposition being passed into potassium iodide, and the liberated iodine titrated with sodium thiosulphate. The ease with which hydriodic acid has been applied in this laboratory as a reducing agent in the determination of arsenic, chloric and antimonic acids‡ has suggested its application for the same end to nitric acid, and the present paper is the account of attempts in this direction.

The Action of Phosphoric Acid and Potassium Iodide upon Nitrates.—The decomposition of the last traces of nitrates in presence of potassium iodide and sulphuric acid does not occur except at very great concentrations, and, as at great concentrations sulphuric acid in presence of hydriodic acid itself liberates iodine, the use of sirupy phosphoric acid to bring about the required decomposition naturally suggested itself. Various attempts to simplify the process while still registering

* Zeitschr. f. angewandte Chemie. 1890, p. 477.
† This Journal, vol. xliv, p. 117.
‡ This Journal, vol. xl, p. 66; vol. xlii, p 220; vol. xlii, p. 213.

the amount of reduction by arsenic acid in the residue proved futile, and a distilling apparatus was found to be necessary. For this purpose a small retort was used, the neck of which was bent downward about two inches from the body, so that the retort itself might be tipped backward, allowing the unbent portion of the retort to run upward, thus guarding against loss from spattering. Into the tubulature of the retort was ground a glass tube drawn out at both ends to serve as a perforated stopper for the entrance of carbon dioxide. The neck was passed through a rubber stopper into a side-neck Erlenmeyer flask, the exit tube of which was prolonged and dropped into a side neck test tube used as a trap. The retort was covered with a simply contrived hood which kept the upper parts warm and prevented the iodine from settling anywhere. In the retort was placed the nitrate with an excess of potassium iodide, and in the receiver a known amount of decinormal solution of arsenious oxide strongly alkaline with hydrogen sodium carbonate and diluted to a convenient bulk. The trap contained nothing but water. The phosphoric acid used was at first 10 cm^3 of strong acid, specific gravity 1·7, with varying amounts of water, but when it was found that the amount of water present was an essential feature, a definite mixture was used as designated in the tables. The acid was added to the retort last of all and after carbon dioxide had been passed for a sufficient length of time heat was applied. The carbon dioxide was evolved in a Bonn generator from materials which had been carefully boiled, and cuprous chloride was added to the acid in the generator to take up the oxygen from any traces of air. Between the introduction of phosphoric acid into the retort and the application of heat a good stream of gas was passed for ten minutes, at the end of which time the bubbles escaping at the last trap were completely absorbed in potassium hydrate of the requisite strength.

The first experiments were in blank with no nitrate present. Upon warming the mixture of phosphoric acid and 2 grm. of the iodide signs of free iodine were developed, and by titration of the contents of the receiver at the end, iodine to the amount of ·0014 grm. was found to have been liberated, either by residual traces of air or by dissociation. The experiment was repeated, but in this case all the water used had been boiled immediately before the experiment and here iodine to the extent of ·0009 grm. only was found to have been liberated. The cause and remedy for this liberation of iodine are discussed presently. A series of experiments was performed to study the action of the reagents when nitrates were present.

The method of procedure was as follows: The nitrate was taken for convenience from a solution of 5 grams in 500 cm^3

of water. The iodide was introduced dry or in solution according to the bulk of water allowable. This mixture was boiled a moment to drive out all air, the phosphoric acid was then added, and carbon dioxide was passed as described, the receiver containing the arsenious oxide and the trap being already in position. It had been found that all but a trace of iodine was caught in the first receiver, so that the rubber stopper closing it could do no harm. When large amounts of nitrate were used the clots of solid iodine settling out in the receiver were dissolved by means of a crystal or two of potassium iodide. The solution in the retort was boiled until it was clear that all the iodine had distilled over, and usually until the boiling in the retort had ceased. It was found advisable to empty the retort so soon as it was cool enough, else the phosphoric acid became unmanageable. The retort after each experiment was washed out with ammonia and water.

The results of these first experiments are shown in Table I.

TABLE I.

	KNO_3 taken.	KI taken.	Water added to 10 cm^3 of phosphoric acid, sp. gr. 1·7.	KNO_3 found.	Error in KNO_3.	Error in HNO_3.
	Series 1.					
	grm.	grm.	cm^3.	grm.	grm.	grm.
1	0·0005	·2	2	0·0009	0·0004+	0·0002+
2	0·0010	·2	2	0·0012	0·0002+	0·0001+
3	0·0020	·2	2	0·0021	0·0001+	0·0001+
4	0·0050	·2	2	0·0055	0·0005+	0·0003+
5	0·0100	·2	2	0·0093	0·0007—	0·0004—
6	0·0100	·2	2	0·0103	0·0003+	0·0002+
7	0·0200	·3	3	0·0216	0·0016+	0·0010+
8	0·0200	·3	3	0·0192	0·0008—	0·0005—
9	0·0200	·3	3	0·0205	0·0005+	0·0003+
10	0·0200	·3	3	0·0205	0·0005+	0·0003+
11	0·0500	·5	6	0·0496	0·0004—	0·0002—
12	0·0500	·5	6	0·0499	0·0001—	0·0001—
13	0·0300	·5	4	0·0293	0·0007—	0·0004—
	Series 2.					
14	0·0616	1·5	1	0·0682	0·0066+	0·0039+
15	0·0570	2·5	1	0·0643	0·0073+	0·0045+
16	0·1030	1·1	1	0·1061	0·0031+	0·0018+
17	0·1062	1·1	1	0·1197	0·0135+	0·0081+

With one or two exceptions the results of Series 1 are fairly good. Those of Series 2 are very bad The only essential difference between the two series is in the dilution of the phosphoric acid used. In the first series there is always enough water present to make the specific gravity of the phosphoric acid no higher than 1·6 for small amounts of iodide and nitrate, and lower than that number when these amounts are increased. The suggestion is obvious that dissociation of

the hydriodic acid may occur at the boiling point of the stronger acid. According to Berthelot* aqueous solutions of hydriodic acid under pressure begin to dissociate at 275° or even under. The temperature of the retort at the end of an experiment was taken and found to be far beyond the range of a thermometer reading to 360°. It is evident, then, that under the conditions there should be opportunity for dissociation. Four experiments in which potassium iodide was treated with phosphoric acid, specific gravity 1·7, undiluted, gave of liberated iodine caught in arsenious acid ·0030 grm. ·0044 grm. ·0049 grm. ·0030 grm. of iodine, corresponding to ·0008 grm. ·0012 grm., ·0013 grm., ·0008 grm. of potassium nitrate respectively. These results would account only in part for the errors noted but, they are in the same direction. Chapman† has found that concentrated hydriodic acid acting upon organic nitrates and nitrites reduces them not alone to nitric oxide but even in part to ammonia. The conditions of the experiments in Series 2 approximate to concentration of the hydriodic acid, and the reaction that Chapman found probably takes place here to a limited extent. Concentration of the hydriodic acid then must be avoided, both to eliminate dissociation and excessive reduction of the nitrate.

Therefore the plan was adopted of diluting the solution, so that the temperature and concentration should be effective in decomposing the nitrate, but should not bring about the complications just mentioned. A blank experiment made thus, 18 cm³ of a solution of phosphoric acid of specific gravity 1·39, being used, gave of liberated iodine only ·0004 grm. corresponding to ·0001 grm. of potassium nitrate. So that under these conditions we may be assured that dissociation occurs if at all to only a slight extent. In the following experiments, therefore, the nitrate is decomposed in presence of dilute phosphoric acid, the dilution and the quantity taken being included in Table II.

The iodine of 41 was collected in potassium iodide and titrated with thiosulphate. Series 3 requires little special comment. The experiments ran along smoothly, the manipulation was easy, the care required in watching very little and the results are fairly satisfactory. The causes leading to the high results of Series 2 seem entirely eliminated by the dilution. Series 4 is a direct continuation of Series 3, differing in the single point that larger amounts of nitrate are handled. These results with some exceptions are decidedly low. It appears that with a fair percentage of water present, as the amounts of nitrate grew larger, the error became a negative one. The explanation for this seemed to be that the last portions of nitric acid must have

* Ann. de Chim. et Phys., (IV), xx, p. 392.
† Journ. of the Chem. Soc., vol. xx, 1867, p. 166.

distilled before decomposition, whenever the original amount was large. Nitric acid was accordingly tested for in the distillate, and to this end all the conditions of the experiment were repeated, except that the receiver contained only water. Of the nitrate 0·4 grm. and of the iodide 4 grm., twice the amount theoretically necessary were put into the retort, and at the end of the experiment the solution in the receiver was boiled with hydrogen peroxide to decompose the hydriodic acid and drive out the iodine, care being taken to keep enough water to hold any nitric acid present. When all the iodine was gone sodium carbonate was added, the solution evaporated and the residue ignited and tested with a saturated solution of manganous chloride in hydrochloric acid, as described in the previous paper above mentioned. By this means 0·0002 grm. potassium nitrate are very easily detected in 10 cm³ of solution. Nitric acid was found in the distillate of this experiment as well as in two others conducted with 0·2 grm. and 0·1 grm. of the nitrate respectively. The residues in the retorts of these three tests showed no trace of nitric acid.

TABLE II.

	KNO_3 taken.	KI taken.	Found.	Sp. Gr. of solution of phosphoric acid.	Amount of sol. used.	Error KNO_3	Error HNO_3
Series 3.	grm.	grm.	grm.			grm.	grm.
18	0·0500	1·	0·0500	1·43	17cm³	0·0000	0·0000
19	0·0200	0·5	0·0201	1·43	17	0·0001+	0·0001+
20	0·0200	1·	0·0198	1·43	17	0·0002—	0·0001—
21	0·0250	1·	0·0250	1·43	17	0·0000	0·0000
22	0·0300	1·	0·0307	1·43	17	0·0007+	0·0004+
23	0·0300	1·	0·0312	1·43	17	0·0012+	0·0007+
24	0·0350	1·	0·0353	1·43	17	0·0003+	0·0002+
25	0·0400	1·	0·0409	1·35	20	0·0009+	0·0006+
26	0·0450	1·	0·0444	1·35	20	0·0006—	0·0004—
27	0·0500	1·	0·0499	1·37	20	0·0001—	0·0001—
Series 4.							
28	0·0600	1·	0·0568	1·37	20	0·0032—	
29	0·0600	1·	0·0575	1·37	20	0·0025—	
30	0·0600	1·	0·0576	1·37	20	0·0024—	
31	0·0600	2·	0·0588	1·37	20	0·0012—	
32	0·0600	2·	0·0605	1·37	18	0·0005+	
33	0·0700	2·	0·0708	1·37	18	0·0008+	
34	0·0800	2·	0·0811	1·37	18	0·0011+	
35	0·0900	2·	0·0842	1·37	18	0·0058—	
36	0·1000	2·	0·0996	1·37	18	0·0004—	
37	0·1000	2·	0·1012	1·37	18	0·0012+	
38	0·1000	1·5	0·0909	1·37	18	0·0091—	
39	0·1000	2·5	0·0979	1·37	18	0·0021—	
40	0·1021	3·	0·1005	1·43	17	0·0016—	
41	0·1032	2·	0·0949	1·43	17	0·0085—	

The process seems reliable enough, then, for estimating nitrates in small quantities not exceeding an equivalent of 0·04 grm. or 0·05 grm. of potassium nitrate. Every experiment performed with quantities not larger than 0·05 grm. has been given here, except four in which an imperfection in the apparatus showed an obvious mechanical loss. The errors in these experiments lie between the extremes of 0 0016 grm. + and 0·0008 grm. − on the nitrate, with an average error of 0·00016 grm. If series 3 alone is taken, in which the dilution of the phosphoric acid was regulated, we have as extreme errors 0·0012 grm. + and 0·0006 grm. − with a mean error of 0·0002 grm +. With quantities of nitrate above 0·05 grm. the process does not seem a safe one, inasmuch as with a moderate amount of water present some nitric acid distils over undecomposed, and with little water present other complications as seen above arise.

The method so far as it is applicable may be summed up as follows. The nitrate not to exceed in amount 0·05 grm. of potassium nitrate, is introduced into a retort, together with ten times its weight of potassium iodide, and 17 to 20 cm^3 of phosphoric acid, of specific gravity 1·43. All water used should be recently boiled. Carbon dioxide is passed from a receiver carefully set up. The neck of the retort passes into a receiver containing a known amount of decinormal arsenious oxide, alkaline with a good excess of hydrogen sodium carbonate and diluted to a convenient bulk. To this flask is attached for additional safety a simple trap containing water. The solution in the retort is boiled until it is clear that no more iodine remains, when the receiver, after proper washing and addition of the liquid in the trap, is titrated with iodine to find the amount of arsenious oxide still left. This gives the measure of the iodine evolved and consequently of the nitrate present, according to the equation

$$2HNO_3 + 6HI = 4H_2O + 2NO + 3I\text{-}I$$

The Decomposition of Nitrates by Antimonious Chloride.—The failure mentioned above, in attempting to use arsenious oxide to register the action of nitric acid, led to the trial of antimonious chloride as a substitute, inasmuch as this substance is easily oxidizable and less volatile than arsenious chloride in presence of hydrochloric acid. This latter fact is of great importance in the decomposition of a nitrate. The point to be tested was whether the complete decomposition of nitrates by the action of antimonious chloride in hydrochloric acid solution, and the absorption of the nascent oxygen to form antimonic chloride would be secured, so that the antimonious chloride left at the end as compared with the amount taken should give the measure of the nitrate used, according to the equation:

$$3SbCl_3 + 2HNO_2 + 6HCl = 3SbCl_5 + 2NO + 4H_2O.$$

Antimony chloride was dissolved in strong hydrochloric acid, and the solution standardized by diluting convenient portions, adding tartaric acid, nearly neutralizing with 25 per cent solution of sodium hydrate, treating with excess of hydrogen sodium carbonate and titrating with decinormal solution of iodine in presence of starch, the blue color being taken as the end reaction.

Known portions of this solution boiled with potassium nitrate for a considerable length of time, then diluted, neutralized and titrated (all a simple quick process), showed oxidation to the extent of about 90 per cent of the nitrate present. The evidence pointed to the conclusion that the nitrate was broken up, but that the residue failed to register the amount of decomposition. The products of decomposition when passed in a current of carbon dioxide into potassium iodide set free iodine, but had no oxidizing effect upon an alkaline solution of arsenious oxide. The conclusion was drawn that nitrosyl chloride was probably given off, which breaking up on contact with water into hydrochloric and nitrous acids exerts no effect upon arsenious oxide in alkaline solution. To see if the nitrosyl chloride was set free in exact measure of the nitric acid lost the following experiments were made.

Into a diminutive retort—made from a pipette shaped like a Liebig's drier and connected by a sliding joint covered by rubber into a Kjehdahl tube used as a receiver, and so placed that carbon dioxide passing through the apparatus should enter from below—lifting the air before it—was introduced the nitrate, dry, washed down with a few drops of recently boiled water, or, if more liquid was required, with hydrochloric acid lest the liquid become too dilute. From a burette a definite amount of antimonious chloride solution, somewhat in excess of the nitrate taken, was introduced. The receiver was charged with 0·25 grm. potassium iodide diluted with recently boiled water and was joined to a trap filled with water. After carbon dioxide was passed through the apparatus for about ten minutes, the solution was warmed on a high boiling bath (103°–107°) to ensure the safety of the retort, to keep the antimony pentachloride from breaking up, to retain the bulk of the acid in the retort and to prevent mechanical loss. This method of procedure was found entirely satisfactory. After fifteen minutes digestion the receiver and trap were washed out and at once titrated with sodium thiosulphate. The residue in the retort was treated exactly as was the antimonious chloride when it was standardized. The solution here must be kept dilute, lest at the great heat caused by neutralizing strong

solutions there be action upon the pentachloride on the part of the small amount of tartaric acid now present. The difference between the trichloride left in the retort and the iodine found in the receiver is the measure of trichloride left unoxidized by the nitrate, and by difference we have the measure of the nitrate present. The results are given in series I and II. In experiments (1) to (8) the receivers were washed with ordinary distilled water; after that with water recently boiled.

SERIES I.

	KNO_3 taken. gram.	KNO_3 corresponding to I found in receiver. grm.	Entire KNO_3 found. grm.	Error in KNO_3. grm.	Error in HNO_3. grm.
1	0·0222	0·0020	0·0233	0·0011+	0·0007+
2	0·0336	00.026	0·0333	0·0003—	0·0002—
3	0·0470	0·0045	0·0471	0·0001+	0·0001+
4	0·0553	0·0057	0·0554	0·0001+	0·0001+
5	0·0664	0·0076	0·0679	0·0015+	0·0009+
6	0·0759	0·0082	0·0752	0·0007—	0·0004—
7	0·0837	0·0103	0·0841	0·0004+	0·0002+
8	0·0934	0·0113	0·0955	0·0021+	0·0013+
9	0·1034	0·0134	0·1036	0·0002+	0·0001+
10	0·0262	0·0024	0·0259	0·0003—	0·0002—
11	0·0127	0·0007	0·0130	0·0003+	0·0002+
12	0·0065	0·0003	0·0067	0·0002+	0·0001+
13	0·0026	0·0001	0·0023	0·0003—	0·0002—
14	0·1232	0·0098	0·1227	0·0005—	0·0003—
15	0·1540	0·0146	0·1540	0·0000	0·0000
16	0·1878	0·0210	0·1865	0·0013—	0·0008—

Three more experiments were performed to see if the titration of the iodine set free in the receiver could be accomplished as well in alkaline solution by means of arsenious oxide. For this purpose the solutions from the receivers were poured into a strong solution of sodium bicarbonate, care being taken to prevent loss during effervescence.

SERIES II.

17	0·0530	0·0052	0·0533	0·0003+	0·0002+
18	0·0547	0·0065	0·0549	0·0002+	0·0001+
19	0·0541	0·0063	0·0537	0·0004—	0·0002—

The results run from extremes of ·0021 grm.+ to ·0013 grm.— with a mean error of ·00016 grm.+, which tends to emphasize the well known fact that it is impossible to remove every trace of air from reagents and generator. The operation is quick, taking in all three-quarters of an hour and requiring very little watching. The experiments given are all that were performed with the apparatus as described, it not having been found necessary to reject a single determination for mechanical mischances.

Neither of the processes described presents in general advantages equal to those of the manganous chloride method to which reference has been made, but under special conditions they may be found useful.

In concluding I would express my thanks to Professor Gooch for valuable advice and assistance given during the course of the investigation.

ART. VII.—*Piedmontite and Scheelite from the Ancient Rhyolite of South Mountain, Pennsylvania;* by GEORGE H. WILLIAMS.

[Published with permission of the Director of the U. S. Geological Survey.]

IN a recent paper on the Ancient Volcanic Rocks of South Mountain in Pennsylvania and Maryland, the identification of the manganese epidote, piedmontite, in the acid lavas was incidentally mentioned.* Several points of interest regarding the occurrence, association and chemical composition of this mineral, which deserve a special notice, have been brought out by its subsequent study.

The acid or rhyolite lavas so extensively developed in South Mountain possess a wide range of color, within which varying shades of pink, maroon and purple are conspicuous. These reddish varieties show many signs of being rich in manganese. Aside from their color, clefts in the rock are often stained black by the oxides of this element, while ordinary weathering not infrequently brings about a similar result. In the basic and more highly ferruginous lavas, conditions favorable to the formation of epidote have at some time obtained to an extent rarely surpassed. Amygdules are filled with this mineral, while in some localities the rock itself is fairly changed to a mass of epidote. Throughout their entire extent the basic lavas have been "epidotized" to a remarkable degree. The tendency to epidote formation is likewise apparent in the acid rocks, especially when they are examined under the microscope. According to the supply of manganese present, however, the common epidote shows every graduation from the faintest rose tinge, through the more pronounced pinks of withamite, to the rich deep carmine of typical piedmontite. All of these varieties frequently occur within the limits of a single thin section, or even as an irregular coloring of a single crystal or group of crystals. In such cases, the deepest color is at the center, as though the

* This Journal, III, vol. xliv, p. 495, Dec. 1892.

growth of epidote had continued, even after the available manganese supply had become exhausted.

The deeply colored, typical piedmontite is irregularly distributed as a microscopic constituent, being most abundant in the reddest rhyolites, and in them, most developed in the feldspar phenocrysts, where it is evidently secondary. At some points a considerable thickness of radiating piedmontite needles occupy cavities and seams in this rock. It is the occurrence of such macroscopic masses of the pure mineral which makes this region an important piedmontite locality; for, while this substance is becoming constantly more widely known as a microscopic rock constituent, the places where it occurs in specimens of macroscopic size and beauty are still very few. In one case piedmontite was found replacing old spherulites and projecting from the sides of ovoid cavities into a mass of enclosing scheelite.

These three types of occurrence will now be described in the inverse order of that in which they have just been mentioned.

1. *Minute crystals in scheelite.*—In the area of rhyolite breccia mentioned in the writer's former paper as occurring in the Buchanan valley, two miles north of the Chambersburg turnpike,* a large block of the acid lava was found behind Musser's store, in which fairly well crystallized piedmontite was abundant. The manganese epidote here occurred wholly or partly filling ovoid areas which resemble old spherulites. The rock itself is banded with lines of flow-structure and has a deep red color from the piedmontite disseminated through it.

Associated minerals are quartz and rarely hematite, but the center of the cavity is usually occupied by a white vitreous mineral, into which the terminations of the minute piedmontite needles project, and which, quite contrary to expectation, proved to be *scheelite.*

The projecting ends of these radiating needles, in spite of their minute size, offer the best material yet found for the study of the crystallographic and optical properties of the South Mountain piedmontite. When a little of the white friable matrix is gently pulverized and mounted in balsam for the microscope a very beautiful result is secured. An abundance of sharply defined crystals are seen bounded by the characteristic planes of epidote, but on account of their intense pleochroism exhibiting, when viewed with one Nicol, many tints of yellow, orange, carmine and amethyst. These little crystals, although very sharp and brilliant under the microscope, are rarely over $0{\cdot}2^{mm}$ in length and $0{\cdot}05^{mm}$ in breadth. They are therefore too small to measure, although some of

* Loc. cit. p. 492, and map on p. 483.

their characteristic forms, as seen under the microscope are shown in fig. 1. Their elongation, as is usual for all epidotic minerals, is invariably parallel to the orthodiagonal axis. Crystals which lie upon their orthopinacoid, as in the figure, are straw-yellow to orange, according to their thickness, when their long direction is transverse to the vibrating plane of the Nicol, and some shade of amethyst when these two directions are parallel. In converged polarized light such sections show an acute positive bisectrix with large optical angle, and optical plane normal to their direction of elongation. Crystals lying on the positive orthodome show the same amethyst shades parallel to their longest direction and deep carmine transverse thereto. The pleochroism is therefore a, yellow; b, amethyst; c, carmine, and the absorption: c > b > a, or c > b = a. In terms of Radde's international color scale the tints of the rays vibrating in these three directions were fixed, as nearly as possible, as a = 7, *s*; b = 23, *l*; c = 25, *m*. This pleochroism agrees, except for differences due to variation in the amount of manganese, with that of all other red epidotes as may be seen from the following table:

Fig. 1.—Piedmontite needles from scheelite, Buchanan valley, Pa. Magnified × 150.

Locality.	*Author.*	a	b	c
St. Marcel	Laspeyres	clear orange	amethyst	blood-red
Sweden	Flink	orange	violet	carmine
Japan	Koto	deep reddish violet	light violet	brownish red
Groix	Lacroix	yellow	very clear rose	bright rose
Glencoe	Lacroix	lemon-yellow	clear rose	light rose
South Mt.	Williams	yellow to orange	amethyst	carmine

The exception in the case of the Japanese piedmontite as given by Koto,* does not agree with my own determination upon a number of specimens from Japan received from him. My examinations of the Japanese piedmontite show it to be quite normal, and give: a, yellow; b, pale violet; c, magenta. I also find the absorption not as Koto gives it, a > c > b, but c > b > a.

* Journal of the College of Science, Imperial University, vol. i, p. 306, 1887.

The determination of the colorless mineral associated with the piedmontite at this locality as *scheelite* was so unexpected that a few words may be devoted to its properties. It is quite brittle and has a vitreous to resinous luster and fairly good pyramidal cleavage. No trace of crystal form was observed, but the cleavage angle measured approximately 100°. In converged polarized light the pyramidal cleavage flakes show a uniaxial figure of positive character and strong double refraction. Moistened with hydrochloric acid the fragments became yellow and then, as the solution dries it becomes a deep blue. Fused with Na_2CO_3 on charcoal and dissolved in water the solution is a deep blue. The phosphor-salt bead is green when hot in the reduction flame, but it remains a deep emerald tint on becoming cold, instead of turning blue as the scheelite bead usually does. The specific gravity determined by a pycnometer with the little material at hand gave 5·61, which, though somewhat low for scheelite, is as good a result as could be expected with the somewhat porous substance.

2. *Radiating aggregates filling veins in the rhyolite.*—The locality which has furnished the greatest abundance of South Mountain piedmontite is on the west flank of Pine Mountain about one mile north of Monterey station. The mineral has here a deep carmine color and forms spherulitic aggregates of needles upon which no trace of crystal form is visible. They are crowded closely together and fill irregular veins which vary in width from 5 or 6^{cm} to the finest possible threads. The average diameter of the radiating aggregates is from 5 to 7^{mm}, although occasional needles have been observed measuring as much as 10^{mm} in length.

In microscopic section these aggregates present a brilliant appearance. The piedmontite needles have the same optical properties as the more perfect crystals already described; but, since there is no parallelism of their $\dot{a}$ and $\dot{c}$ axes, the fibers all show an amethystine color in the direction of their elongation, but various shades of carmine, yellow and orange in transverse directions. Some of the needles show in their pleochroism a complex twinning structure like that figured by Laspeyres.* The microscope shows further that the needles of these radiating aggregates are minutely intergrown with clear limpid quartz. This mixture is so extremely intimate as to render the obtaining of pure material for analysis very difficult. A powder obtained with the Thoulet solution was carefully analyzed by Mr. W. F. Hillebrand, of the U. S. Geological Survey, with the following result:

* Zeitschrift für Kryst., vol. iv, Pl. XI, fig. 8, 1880.

SiO_2	47·37
Al_2O_3	18·55
Ce_2O_3	0·75
R_2O_3 (other rare earths)	1·28
Fe_2O_3	4·02
Mn_2O_3	6·85
MnO	1·92
CaO	15·82
MgO	0·25
K_2O	0·68
Na_2O	0·23
H_2O	2·08
CuO	0·11
PbO	0·14
Total	100·05

The silica is here 10 per cent too high for epidote, but as the microscope showed that the only impurity was pure quartz, it seemed quite justifiable to recalculate the analysis after deducting 10 per cent of this substance. To substantiate this conclusion another separation was attempted with greater care. The piedmontite was very finely pulverized and only that portion used which fell in a solution of methelyne iodide having a specific gravity of 3·32. The microscope showed that there was still a small quantity quartz admixed, although much less than in the preceding instance. A determination of the silica of this powder by Mr. Hillebrand gave 40·08 per cent. It seems therefore certain that the recalculation of the analysis given above on a basis of 37·37 per cent silica would give very nearly the composition of our piedmontite. The result thus secured is as follows:

SiO_2	37·37
Al_2O_3	22·07
Ce_2O_3	0·89
R_2O_3 (other rare earths)	1·52
Fe_2O_3	4·78
Mn_2O_3	8·15
MnO	2·285
CaO	18·825
MgO	0·30
K_2O	0·81
Na_2O	0·27
H_2O	2·48
CuO	0·13
PbO	0·17
Total	100·05

This analysis is of especial interest in showing that the South Mountain piedmontite is a connecting link between three recognized members of the epidote group. In the first place, the amount of cerium and other rare earths which it contains indicates a considerable admixture of the allanite or orthite molecule; while the presence of both manganous and manganic oxides gives this mineral a position intermediate between true piedmontite and the mangan-epidote of Flink. Copper occurs extensively in the rocks which carry the piedmontite.

Another locality for piedmontite filling veins in the rhyolite was found near the head of Miney Run below the Clermont Hotel. While similar to that on Pine Mountain, the mineral is here less abundant.

3. *Piedmontite as a microscopic constituent of the rhyolite.* —Although piedmontite has as yet been observed in macroscopic quantities in the South Mountain rhyolite only at the three localities above mentioned, it is quite generally disseminated as a microscopic constituent. Other occurrences like those already described will doubtless come to light as the detailed examination of the rhyolite area proceeds.

The reddest rhyolites contain microscopic piedmontite most abundantly and this color, as in the case of the well-known "porfido rosso antico," seems to be due to the mineral. The most representative specimens of this variety are from the small area of rather coarse and porphyritic rhyolite occurring just at Monterey station, Pa. This rock, which may be regarded as a type of all the others of this region like it, has a micropoikilitic* groundmass enclosing good-sized phenocrysts of checkered anorthoclase and smaller ones of rounded quartz. It shows no particular evidence of dynamic action, though there is some secondary quartz and sericite present. The groundmass is full of black specks, probably manganese oxide resulting from the alteration of piedmontite, while there is every indication that the latter mineral, along with its associated rose and common epidote, is itself always of secondary origin. It occurs in veins or cracks in the feldspar phenocrysts and groundmass or in isolated patches, usually in association with secondary quartz, epidote and black manganese oxide. The piedmontite is not infrequently surrounded by a zone of pale rose or colorless epidote, which, however, seems to be rather granular than of continuous crystalline structure with the deep red mineral in the center (fig. 2).

As the microscopic piedmontite agrees in all its physical properties with the macroscopic, except for its greater tendency to mix in all proportions with the epidote molecule, no

* G. H. Williams: "On the use of the terms poikilitic and micropoikilitic in petrography;" Journal of Geology, vol. i. p. 176, 1893.

attempt was made to isolate it. There is no reason to believe that it is not the same mineral as that concentrated in the veins.

Fig. 2.

Occurrence of microscopic piedmontite in minute veins with secondary quartz and surrounded by rims of epidote. Magnified × 25.

As piedmontite is constantly increasing in importance as a rock constituent, it has appeared to the writer worth while to record all occurrences heretofore published. As far as possible he has made a comparative study of these occurrences.*

We notice in epidote a tendency to form red varieties, just as, in the case of hornblende, there is a tendency to form blue ones (glaucophane, riebeckite, gastaldite, crocidolite). Thulite is red zoisite. The red epidote of Rotherkopf in the Tyrol† and the withamite of Glencoe in Scotland contain very little manganese, and are comparable with the rose epidotes associated with the microscopic piedmontite of South Mountain and Japan.‡ The recorded piedmontite occurrences which the writer has been able to find are as follows:§

1. *With manganese ore deposits.*—San Marcel,* Viù, and Mezzenile, Italy‖ (piedmontite); Jakobsberg,* Sweden¶ (mangan-epidote, with MnO only).

2. *Spherulitic aggregates as veins in eruptive rocks.*—Glencoe,* Scotland** (withamite); South Mountain,* Penn.

3. *Secondary constituent of eruptive rocks.*—"Porfido rosso antico," Djebel Dokhan,* Egypt††; Quartz porphyries of Missouri;* ‡‡ granulite of Haute-Loire, France;§§ South Mountain,* Penn.

* For assistance in gathering material for this study the writer would express his gratitude to Mr. C. S. Bement of Philadelphia; Mr. J. S. Diller of Washington; Prof. L. V. Pirsson of New Haven; Prof. B. Koto of Tokyo; Prof. G. Flink of Stockholm and Prof. A. Lacroix of Paris.

† H. Bücking: Zeitschr. f. Kryst., vol. ii, p. 384, 1878.

‡ B. Koto: Jour. Coll. Sci., Imp. Univ. Japan, vol. i, p. 310, 1887.

§ Asterisk denotes specimens studied by this writer.

‖ Laspeyres: Zeitschr. f. Kryst., vol. iv, p. 435, 1880; Jervis, quoted by Hintze: Handb. Min., p. 255, 1890.

¶ G. Flink: Zeitschr. f. Kryst., vol. xv, p. 88, 1889.

** D. Brewster: New Edinb. Journ. Sci., vol. ii, p. 218, 1825; Heddle: Min. Mag., vol. v, p. 15, 1882; Lacroix: Bull. Soc Min. de Fr., vol. vi, p. 75, 1886.

†† H. Rosenbusch: Die mass. Gest., 1st ed., p. 290, 1877; 2d ed., p. 472, 1887; Th. Liebisch: Zeitschr. d. geol. Ges., vol. xxix, p. 717, 1877.

‡‡ E. Haworth: Inaug. Dissertation, Am. Geologist, vol. i, p. 365, 1888.

§§ Lacroix: Minéralogie de la France, vol. i, p. 155, 1893.

4. *In crystalline-schists.*—Chlorite sericite gneiss and glaucophane schist, Japan;* on ilmenite from mica-schist, Island Groix, France;† in gabbro-diorite (alteration product of hornblende), Chichibu, Japan.‡

The writer is indebted to Messrs. Diller and Pirsson for two occurrences of piedmontite in quartz-porphyry which have not as yet been described. The first is in the porphyries and felsites of the Boston basin. Although Mr. Diller does not mention this mineral in his paper on these rocks, it occurs in at least six sections which were kindly loaned the writer for examination. From Mr. Pirsson the writer has a section of a porphyry almost identical with the common South Mountain type, which comes from the "Archæan area of Georgia near Tennessee." It has a finely developed micropoikilitic groundmass, considerable rather pale piedmontite (perhaps withamite), and is especially interesting as showing the persistence of the rhyolite to the southern end of the Appalachian region.

Petrographical Laboratory, Johns Hopkins University,
Baltimore, March 24, 1893.

Art. VIII.—*The Cambrian and the Ozark Series;* by G. C. Broadhead.

In the Missouri Geological Report, 1873–74, the writer announced the finding of *Lingulella Lamborni* Mk. in the lower Magnesian limestone beds of Madison County and from that evidence the beds were referred to the age of the Potsdam. I have also obtained from the same beds a *Scolithus* and *Obolella polita.*

In various papers published by C. D. Walcott notably in this Journal for December, 1884, and in Bulletin 81 of the U. S. Geol. Survey—Correlation papers—Cambrian he has referred the Potsdam group to the age of the Upper Cambrian.

In an article by the writer of this paper read before the Am. Assoc. Adv. of Science, Cleveland meeting, 1888, and published in the American Geologist, January, 1889, entitled "The Geological History of the Ozark Uplift," the rocks of the Ozarks were defined and I made the statement that the Magnesian Series of the Ozarks were equivalent to the Upper Cambrian of C. D. Walcott. In a subsequent article published in the American Geologist for July, 1891, entitled the "Ozark Series" I have briefly described the several members of the

* B. Koto: Jour. Coll. Sci., Imp. Univ. Japan, vol. i. p. 303, 1887.
† Lacroix: Bull. Soc. fr. de Min., vol. xi, p. 148, 1888.
‡ T. Harada: Die Japanischen Inseln, Erste Lief. Berlin, 1890, p. 75.

series and stated that the second Magnesian limestone and the other series below to the Archæan seem to correspond with the description and position of beds referred by Mr. Walcott to the Upper Cambrian. I now make the additional statement that there is a similarity in character and composition of the entire series from the top of the first Magnesian to the lowest member of the Ozark series so as to make it seem proper to class the various members in one series the "Ozark Series."

The author of the article on the Cambrian and Ozark Series published in this Journal for March, 1893, would make us believe that he was the first person who had suggested the appropriateness of assigning this series to the age of the Cambrian, but as I have above stated the Cambrian age had been suggested before. Again, referring to Bulletin, No. 81, Correlation papers, Cambrian, Mr. Walcott says that "The Cambrian rocks occur in the southeastern portion of the State, about the Ozark Uplift. In several other places in the same Bulletin the Cambrian and Potsdam of Missouri are referred to. In the article above referred to, published in this Journal for March, 1893, a statement is made on pages 221 and 222 that in view of the recent work of the Missouri Geological Survey a new classification would be necessary. If necessary, it would be either for correction of former work done, or else on account of new discoveries. I do not consider that previous or present facts can justify any particular change.

Prof. Swallow defined the Magnesian limestone series (Ozark Series) and gave names to the principal beds in their order thus:

First Magnesian limestone.
First or Saccharoidal sandstone.
Second Magnesian limestone.
Second sandstone.
Third Magnesian limestone.
Third sandstone.
Fourth Magnesian limestone.

The original section is in the main correct. Still there are certain beds found in one part of the State that cannot be entirely differentiated at other localities and some beds found at one place may be wanting at other places. Prof. Swallow recognized a third and a fourth Magnesian limestone on the Osage. The formation known as the Third Magnesian limestone includes certain beds which cannot be distinguished from the fourth Magnesian and it may be that the lower limestones of Madison County are of the age of the fourth Magnesian; if so, the two are not separated by a sandstone in Southeast

Missouri. On the Missouri River I have observed at several places lenticular beds of sandstones intercalated in the Second Magnesian and these sandstones sometimes may be traced for several miles, or as much as 15 miles.

In the well bored at the Insane Asylum, St. Louis, we find the following series:

			Total depth.
1.		Loess to	40 feet.
2.		Coal measures to	120 "
3.		Lower Carboniferous "	883 "
4.		Lower Silurian "	1304 "
5.	Ozark Series.	First Magnesian limestone "	1452 "
6.		First sandstone "	1585 "
7.		Second Magnesian limestone "	2102 "
8.		Second sandstone "	2184 "
9.		Magnesian limestone, very cherty "	2671 "
10.		Magnesian limestone and sandstone "	2843 "
11.		Sandstone "	2880 "
12.		Limestone "	3022 "
13.		Sandstone "	3120 "
14.		Magnesian limestone "	3504 "
15.		Sandstone "	3545 "
16.		Sandstone and limestone "	3555 "
17.		Sandstone, there may be granite at base,	3843 "

This section indicates other sandstones besides the 1st, 2d and 3d. They may be local beds. My general section in Madison County is as follows:

1.	Chert beds	125 feet.
2.	Magnesian limestone with chert and quartz	100 "
3.	Magnesian limestone	125 "
4.	Gritstone and Lingula beds	50 "
5.	Marble beds	5 to 25 "
6.	Sandstone and conglomerate	5 to 90 "

Near the Iron Mountain, Conglomerate rests on the Porphyry; eastwardly on St. François River in Madison County the lower beds of the sandstone are pebbly and rest upon granite. Near Fredericktown the series appears thus:

1. Magnesian limestone.
2. Gritstone.
3. Sandstone.
4. Red Slaty sandstone.
5. Granite.

Ten miles west, No. 4, of this section is over 20 feet thick, with layers of sandstone and conglomerate above.

In the northern part of Madison County the marble beds are wanting, but the gritstone beds are present. In the southern

portion of the county we find both. On west side of St. François River not far from mouth of Leatherwood Creek the section shows:

1–4 feet Magnesian limestone.
2–4 feet Gritstone.
3–9 feet of Magnesian limestone.
4–3 feet of Gritstone.
5–11 feet of Magnesian limestone.
6–20 feet of Marble beds.

On Twelve Creek I have found the Gritstone beds resting on the marble which in turn rests upon the porphyry. In this way I obtained my general section of Madison County as above. On Marble Creek in Iron County the Magnesian limestones are seen resting directly upon the porphyry.

The sandstone and the Marble beds not being persistent are found at some places resting upon the porphyry or granite (Archæan) at other places the limestones rest directly upon the Archæan. The upper beds of the Ozark Series are in the main persistent. Near Augusta the regular succession, from first Magnesian to second Magnesian is preserved. At Crystal City, Pacific and Westpoint, Ill., the two upper members are well exposed. On the Gasconade and Osage the second and third Magnesian limestones with the separating and incumbent sandstones are well marked. So, taking all the evidence in the case one had better go very slow before he attempts a new arrangement or classification.

Art. IX. — *A One-Volt Standard Cell;* by Henry S. Carhart.

[Read before the National Academy of Sciences, Washington, April 21, 1893.]

The calomel cell, consisting of mercury in contact with mercurous chloride and zinc in a solution of zinc chloride, was first described by von Helmholtz in 1882.* Without any knowledge of its previous invention I made the same cell six years ago and have still the first sample made at that time. Ostwald† refers to a calomel cell giving one volt E. M. F. at 15° C., the density of the zinc chloride being 1·409 at 15°, and the temperature coefficient +·00007 volt per degree.

Within the last few months I have taken up the calomel cell again with a view of adjusting it to precisely one volt, making a careful determination of its temperature coefficient, and investigating its reliability.

* Sitzber. der Akad. der Wiss., p. 26, Berlin, 1882.
† Zeitschrift für Physikalische Chemie, vol. i, p. 403.

It is now well known that the E. M. F. of a voltaic cell with zinc immersed in a solution of one of its salts decreases with increase of density of the solution.* Within limits therefore the E. M. F. of a cell can be varied by changing the density of the solution of the zinc salt. Thus the E. M. F. of a Clark cell was found to vary from 1·434 volts with a solution saturated at 20° C. to 1·481 volts with a 5 per cent solution, a variation of nearly three and one-third per cent.

The variation of the E. M. F. with density is even greater in the case of zinc chloride. With zinc chloride 16 per cent increase of density produces 3·5 per cent decrease in E. M. F. An equal increase of density of zinc sulphate is accompanied by only half the percentage decrease of E. M. F. Hence greater care is necessary in standardizing a solution of zinc chloride than of zinc sulphate.

Taking the Clark cell with excess of crystals of zinc sulphate as the standard, having an E. M. F. of 1·434 volts,† at 15° C., I have found that the density of the zinc chloride solution required to give one volt is 1·391 at 15° C. Ostwald's density gives too low a value. It was probably adjusted to correspond with the legal ohm.

The cell is made in the same form as my Clark standard. In the bottom of the tube is pure mercury in contact with a platinum wire; on this a paste of mercurous chloride and the zinc chloride solution; a cork diaphragm follows, holding the mercury and paste firmly in position, especially with some asbestos packing under the cork; zinc chloride is then added to the proper depth, and an amalgamated zinc rod, supported by a cork, completes the electrical combination of parts. The cell must be hermetically sealed as usual. Such a cell is perfectly portable and gives promise of long life. Its internal resistance is about 1500 ohms, and it does not appear to suffer permanent change by heating to 50° C. or even to 60°. The cell six years old already mentioned is still in good condition and has apparently maintained its E. M. F.

An interesting feature of this cell is its small positive temperature coefficient. It is well known that the coefficient of the Clark and the Daniell standard is negative. The calomel cell has a coefficient of about +·00009 within working limits of temperature. In the following table will be found the data of one series of observations on the temperature coefficient:

* Carhart, this Journal. Nov. 1884, p. 374.

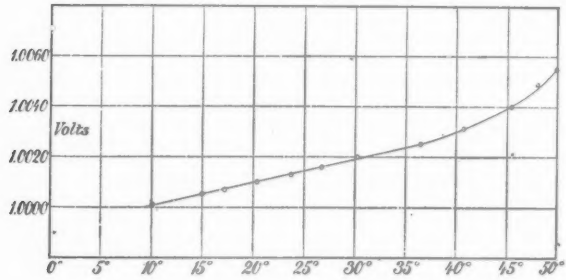
† Report of the B. A. Committee, Edinburgh Meeting, 1892.

TABLE I.

No. 30. Clark.		No. 8. $ZnCl_2$		
Resistance to balance.	Temp. C.	Resistance to balance.	Temp. C.	Electromotive force in volts.
9401	18°·25	6572	13°·7	1·0000
		6608	48·9	1·0055
		6604	48·0	1·0049
		6598	45·4	1·0040
		6592	40·7	1·0031
		6589	36·4	1·0025
9402+	18°·25	6586	30·2	1·0020
		6583	26·7	1·0016
		6581	23·7	1·0013
		6579	20·4	1·0010
		6577	17·2	1·0007
		6576	15·0	1·0005
9403	18°·1	6573·5	10·0	1·0001

The E. M. F. of the Clark is taken as 1·434 at 15°; temperature coefficient −·00077. It will be observed that the cell does not recover its normal E. M. F. immediately on descending temperatures. This hysteresis phenomenon however is small, amounting only to an error equivalent to about three degrees of temperature. The entire change of temperature of about 40° took place within three hours. The observations of the table are plotted in the curve of fig. 1. The curve is approximately a straight line between ten and forty degrees. Beyond

1.



this point the coefficient increases rapidly. The equation of the curve contains not only a quadratic term but one which is a function of a still higher power of the temperature. The following equation fits the observations fairly well:

$$E_t = 1 + \cdot 000085(t-15) + \cdot 0000006(t-15)^2 + \cdot 00000001(t-15)^3.$$

Between ten and thirty degrees the relation between E. M. F. and temperature may be expressed as follows:

$$E_t = 1 + \cdot 000094(t-15).$$

The coefficient is therefore a little less than $\frac{1}{1000}$ per cent per degree. A neglected variation of temperature of 10° C. can cause an error of only $\frac{1}{100}$ per cent.

In another paper* I have given an analysis of the temperature coefficient of both the Clark and the Daniell cell when the former contains no excess of zinc sulphate crystals, and have shown that this coefficient is a purely thermo-electric phenomenon at the contact of a metal and a liquid. Further investigations confirm this conclusion that the temperature coefficient of a voltaic cell is the result of the superposition of the two thermo-electromotive forces of the metal and the salt in contact with it on the two sides of the cell, whenever this coefficient is not complicated with oxidation effects and the solution and recrystallization of salts. In the old Clark cell almost exactly half the temperature coefficient is due to changes in density of the solution by reason of the presence of an excess of zinc sulphate crystals.

These dissolve when the temperature rises and again slowly crystallize out on a falling temperature. Time is required for diffusion, and the cell is therefore slow in reaching its electrical equilibrium after a temperature change. This time lag may extend over several days. It is very appreciable when the temperature change does not exceed one degree an hour.

Whether a resultant temperature coefficient shall be positive or negative depends upon the relative values and the signs of the two thermo-electromotive forces at the two sides of the couple. To measure these electromotive forces of thermal origin I have made use of an experimental cell consisting of two glass tubes 12^{cm} long and 1^{cm} to 2^{cm} in diameter, joined near the top by a small tube 17^{cm} long, having near the middle a narrow bore made by thickening the walls of the tube. When it is desirable to use two liquids a plug of asbestos is placed at the narrow part of the connecting tube to aid in filling without admixture of the liquids and to diminish diffusion. When the thermo-E. M. F. between a metal and a liquid is to be determined the experimental cell is filled with the liquid and wires of the same metal, cut from one piece, are inserted in the two limbs. One limb is then kept in melting ice and the other is raised to different temperatures, and the resulting E. M. F. measured. For this latter purpose the most exact method, giving practically an electrostatic measurement, is to balance the E. M. F. of a standard cell against the fall of potential over the requisite resistance in a circuit of constant high resistance (10,000 ohms), as in the Rayleigh or compensation method of comparing electromotive forces.† The experimental cell is then

* London Electrician, June 12, 1891; Carhart's Primary Batteries, pp. 136–150.
† Phil. Trans., Part II, 1884, p. 441.

put in series with the standard cell, and the resistance in the shunt of the main circuit required to maintain a balance shows both the value and the direction of the E. M. F. of the experimental cell as compared with the standard.*

By this method the mean thermo-E. M. F. of $Cu-CuSO_4-Cu$ per degree between 0° C. and 50° C. I have found to be +·00073 volt. The positive sign indicates that the metal in the warm solution is positive externally to the one in the cold, or the metal in the cold plays the part of the zinc of a voltaic couple. Bouty† gives the E. M. F. of $Fe-FeSO_4-Fe$ as zero. It follows that a couple consisting of $Fe-FeSO_4-CuSO_4-Cu$ should have a positive temperature coefficient, and this coefficient should be the same whether the whole cell is heated or only the copper—copper sulphate side. Experiment confirms the first conclusion at least. The E. M. F. of the cell at 15° C. was found to be 0·625 volt, and at 29°·4 C., 0·637 volt. The change is therefore +0·000833 volt per degree and the coefficient is $0{\cdot}000833 \div 0{\cdot}625 = 0{\cdot}0013$, or over $\frac{1}{10}$ per cent.

Theoretically it should be

$$0{\cdot}00073 \div 0{\cdot}625 = 0{\cdot}0012.$$

The above combination is now used as an iron gravity battery, and the change in its E. M. F. with a sudden change of the temperature of the room had attracted my attention before I had investigated the temperature coefficient. After the above iron-copper cell had been left standing for twenty-four hours, with a piece of iron wire in the connecting tube of the experimental cell to intercept the $CuSO_4$ which might diffuse over, the E. M. F. was found to be 0·651 volt at 14°·4 C.; and for a range of 7·7 degrees the temperature coefficient was 0·0012. This is exactly the value obtained from theoretical considerations.

Another case in point is that of the voltaic series

$$Ni-NiSO_4-CuSO_4-Cu.$$

The E. M. F. was quite variable and only an approximate measurement could be made. The temperature coefficient was positive and equal to 0·0084, or over $\frac{8}{10}$ per cent per degree C. The actual change in E. M. F. was greater than this, for the E. M. F. continued to fall on standing and the change by heating was thus in part masked.

The thermal-E. M. F. of copper—copper sulphate is positive, while that of nickel—nickel sulphate is negative. Hence the temperature coefficient of the above series should be positive and equal to the sum of the two thermal E. M. F.'s. The result is positive but not equal to the sum of the two thermal

* Carhart's Primary Batteries, p. 137. † Journal de Physique, vol. ix, p. 229.

E. M. F. values. Perhaps no closer numerical agreement could be expected in the case of a variable E. M. F.

In the light of the above conclusions and with thermo-electric data furnished by Bouty and by Chroustchoff and Sitnikoff* it is easy to draw the conclusion that the temperature coefficient of the calomel cell should be negative and of small value. The thermo-E. M. F. or value of $\frac{dE}{dT}$ for $Zn - ZnCl_2 - Zn$ is given by Bouty as 0·000696; Chroustchoff and Sitnikoff found that of $Hg - Hg_2Cl_2 - ZnCl_2 - Hg_2Cl_2 - Hg$ to be 0·00066 between 0° and 50° C.

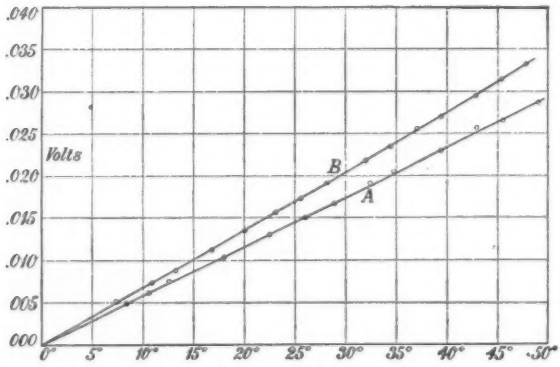
Hence the coefficient should be,

$$0{\cdot}00066 - 0{\cdot}000696 = -0{\cdot}000036.$$

The value of $\frac{dE}{dT}$ for zinc in zinc salts given by Chroustchoff and Sitnikoff would give a larger negative coefficient than the above.

I have therefore investigated this subject to ascertain if this case furnishes an exception to the law of temperature coeffi-

2.



cients already announced. The result confirms the law and shows Bouty's result to be in error The determinations were made by means of the experimental cell in the manner already indicated. Tables II and III contain the observations which are expressed graphically in the two curves of fig. 2, in which

A. relates to $Zn - ZnCl_2 - Zn$, Table II, and
B. to $Hg - Hg_2Cl_2 - ZnCl_2 - Hg_2Cl_2 - Hg$, Table III.

* Comptes Rendus, vol. cviii, 1889, p. 937.

TABLE II.

Difference of Temperature.	Total E. M. F. in volts.	E. M. F. per degree C.
49°·0	·02876	·000587
45·5	·02662	·000585
42·9	·02570	·000579
39·4	·02295	·000582
34·8	·02050	·000589
32·4	·01913	·000590
28·9	·01668	·000577
26·1	·01499	·000574
22·5	·01301	·000578
18·0	·01040	·000580
12·6	·00750	·000595
10·6	·00612	·000577
8·4	·00490	·000583
	Mean,	+·000584

TABLE III.

Difference of Temperature.	Total E. M. F. in volts.	E. M. F. per degree C.
47°·8	·03314	·000693
45·4	·03146	·000693
42·8	·02949	·000689
39·4	·02706	·000686
37·1	·02554	·000688
34·4	·02340	·000680
32·1	·02174	·000677
28·2	·01928	·000687
25·6	·01729	·000675
23·1	·01561	·000675
20·1	·01353	·000673
16·8	·01125	·000669
13·2	·00882	·000668
10·9	·00730	·000669
7·4	·00517	·000698
	Mean,	+·000681

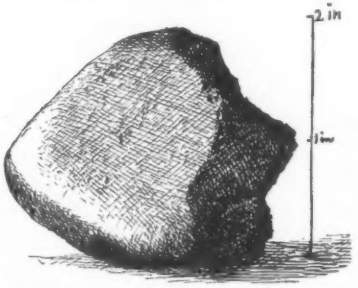
Both of these thermal E. M. F.'s are positive. The temperature coefficient should therefore be

$$0{\cdot}000681 - 0{\cdot}000584 = 0{\cdot}000097 \text{ as a mean.}$$

This corresponds very closely indeed with the value found by observation on a one-volt cell. It will be observed that it is only necessary to take the difference of the above electromotive forces to obtain the temperature coefficient, since the E. M. F. of the cell is one volt. The coefficient is positive because the value of $\frac{dE}{dT}$ for the positive side of the cell is in excess of that for the negative side.

ART. X.—*Cross Roads Meteorite;* by EDWIN E. HOWELL.

LAST September I purchased from Mr. B. E. Barnes of Boyett, N. C. (who secured it of the finder about three weeks after it fell), a small aerolite which is here figured. It fell in the early morning about five o'clock, May 24th, 1892, in the township of Cross Roads, Wilson Co., N. C., and was seen by a young man named Gray Bass, who was only about two hundred feet distant. He seems to have been frightened by the sight and sound and waited two or three hours before going to the spot. With a stick he then dug up the meteorite, which penetrated 4 or 5 inches into the packed but sodded earth close by a road bed. Young Bass also states that some of the grass near the spot was dead and looked as if killed by fire! He further says that he thought the meteorite came from the northwest. From the testimony of others who heard it, however, it seems undoubtedly to have come from exactly the opposite direction, having been heard as far away as eighteen miles in a S. E. direction. Among those who heard it was a colored boy one quarter of a mile to the S. E., Mieajoh Hales, four to six miles to the S. E. who describes the noise as "somewhat like thunder accompanied by lesser sounds like the report of pistols or the snapping of burning reeds." Another man, Edward S. Dees, distant five or six miles nearly south, wrote in answer to my inquiries, that one clear morning before sunrise sometime in May he was in the open field and heard a peculiar noise which lasted a quarter of a minute and sounded like "a freight train crossing a trellis"—thought it came from the S. W. Wm. B. Scott, about eighteen miles to the S. E., writes that before sunrise on the 24th of May he and a neighbor heard a noise "something like a sky rocket but more like thunder which went off in a northern direction."



Mr. Barnes sent the stone first to the National Museum and a fragment weighing 4½ grams was broken off. With the exception of this piece nothing has been taken from it since it was picked up; several small chips however were broken off before it reached the ground and the broken surface partly crusted again. It now weighs 157 grams and it would probably have weighed about 200 grams, if it had reached the earth unbroken.

The thick even crust coating the meteorite indicates that it was a complete individual and not one of a shower. The freshly broken surface is of the usual gray color and the structure is chondritic. The dimensions of the stone are 1, 2 and 2½ inches. The specific gravity is 3·67, which is somewhat greater than most meteorites of this class, indicating a little more iron.

Washington, June 13, 1893.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Study of Chemical Reactions by means of the Refractive Index.*—It has been shown by Féry that the occurrence of chemical changes in solution may be detected and studied, by comparing the refractive indices of solutions containing two substances which are capable of acting one on the other, with those calculated on the assumption that the observed index is the mean of the indices of the two constituents. In a solution containing sodium hydroxide and nitric acid for example it was observed that the maximum deviation of the experimental from the calculated values occurred in a solution containing 8 parts of NaOH and 12·31 parts of HNO_3 in 100 of water, the ratio 12·31/8·00 being nearly equal to that of $HNO_3/NaOH$. When alkalies are mixed with sulphuric acid, there are two points at which changes of the refractive index occur in the curve, one corresponding with a mixture that would form an acid salt, the other to one that would form the normal salt. In the case of phosphoric acid the curve has three such points. In cases where no chemical action occurs, the observed and calculated values for the indices of refraction are found to coincide, the curve for the refractive indices of such mixtures being a continuous straight line. Moreover, the author has observed certain other slight breaks and changes in the refractive-index curve, which he attributes to the formation of special hydrates by the union of water with the substances under examination. In the case of sulphuric acid, a special study showed that such breaks occurred with solutions corresponding to hydrates of H_2SO_4 with one, one and a half, two and four molecules of water respectively.—*C. R.*, cxv, 1309; *J. Chem. Soc.*, lxiv, ii, 201, May, 1893. G. F. B.

2. *On the Preparation of Chlorine by means of Nitric Acid and Manganese dioxide.*—Several years ago Schlösing proposed a process for preparing chlorine by acting on hydrochloric acid with manganese dioxide and nitric acid; the reaction taking place according to the equation:

$$MnO_2 + (HCl)_2 + (HNO_3)_2 = Mn(NO_3)_2 + (H_2O)_2 + Cl_2$$

and evolving theoretically the whole of the chlorine contained in the hydrogen chloride. In practice, using the dioxide and the hydrochloric acid (sp. gr. 1·184) in the proportion given in the equation, and nitric acid (sp. gr. 1·4245) in excess to the extent of 75 per cent, a yield of 98–99 per cent of the calculated quantity of chlorine is obtained. To the acid mixture one-seventh of its volume of water is added and the whole is heated to 135°. Lunge and Pret have studied this reaction more completely. They find that the resulting manganese nitrate may be entirely converted, by heating, into manganese dioxide and the lower

oxides of nitrogen; the reaction beginning somewhat suddenly and vigorously, about 180°–190° and being completed at 250° in a proportionately shorter time. The evolved nitrogen oxides, by mixture with air and conduction into water are re-converted into nitric acid. But this regeneration is never complete; even when conducted at the ordinary temperature or in fact at a lower one. Moreover, since there is also a loss of nitric acid during the evolution of the chlorine—though in what form is doubtful, a portion probably escaping as nitrosyl chloride—the authors conclude that owing to this considerable loss of nitric acid, amounting at least to 10 per cent and perhaps to 16 per cent of the acid used, the chlorine method of Schlösing, commercially, has material disadvantages.—*Ber. Berl. Chem. Ges.*, (Ref.) xxvi, 309, May, 1893.

G. F. B.

3. *On Complex Acids containing Septivalent Iodine.*—Blomstrand has described certain complex inorganic acids containing the quinquivalent group IO of periodic acid, analogous to the trivalent group PO in phosphoric acid. These acids are classed as monomolybdoperiodic acid $IO(OH)_4 . O . MoO_2 . OH$, tetramolybdoperiodic acid $. IO(OH)_3(O . MoO_2 . O . MoO_2 . OH)_2$ and hexamolybdoperiodic acid $IO(OH)_2(O . MoO_2 . O . MoO_2 . OH)_3$. The hexamolybdoperiodates were prepared by heating periodic acid or the corresponding periodate with molybdic acid and the carbonate of the same metal, in aqueous solution, until the whole had dissolved, and then allowing crystallization to take place spontaneously. In some cases a dilute solution of the acid itself was prepared from a mixture of periodic acid and barium molybdate by adding sulphuric acid, and this solution was then neutralized by a metallic carbonate. The acid solution on evaporation yielded a transparent amorphous mass with no trace of crystallization. The sodium salt crystallizes with $(H_2O)_{17}$ in rhombohedrons, and with $(H_2O)_{13}$ in triclinic prisms; the hydrogen potassium salt crystallizes with $(H_2O)_{12}$ in four or six sided triclinic plates; and the lithium salt $Li_5Mo_6IO_{24}(H_2O)_{15}$ crystallizes in rhombohedrons. The ammonium and the calcium salts, and also double salts of strontium-sodium, barium-sodium and manganese-sodium are described. By treating the ammonium salt of the hexa-acid with ammonia, the tetramolybdoperiodate is obtained; and by treating the sodium salt similarly, ammonium-sodium monomolybdoperiodate is prepared crystallizing in quadrangular triclinic plates containing four molecules of water.—*Zeitschr. anorg. Chem.* i, 10; *J. Chem. Soc.*, lxiv, (ii), 122, March, 1893.

G. F. B.

4. *On the Refractive Indices of liquid Oxygen, Nitrogen Monoxide and Ethylene; and on the Spectrum of liquid Oxygen.*—Liveing and Dewar have determined the constant of refraction $(\mu_D-1)/d$ for oxygen at its boiling point $-182°$ and found it to be 0·1989, it refraction-equivalent at this temperature being 3·182. Using the formula $(\mu^2-1)/(\mu^2+2)d$, the corresponding values are 0·1265 and 2·024. Liquid nitrogen monoxide at $-90°$ gives for

the value of $(\mu_D-1)/d$, 0·2634, and for $(\mu^2-1)/(\mu^2+2)d$, 0·163; the molecular refraction-equivalents being 11·587 and 7·163 respectively. Ethylene at −100° gives 0·627 for the value of $(\mu_D-1)/d$ and 0·384 for $(\mu^2-1)/(\mu^2+2)d$; the corresponding numbers for gaseous ethylene being 0·578 and 0·385. By viewing the incandescent pole of the electric arc through a column of three inches of liquid oxygen, with a spectroscope having two calcite prisms of 30° and one of 60°, the red potassium lines being used as reference lines, the authors have obtained the absorption spectrum of this element. In place of the solar line A, a band was observed having a sharp edge on the less refrangible side and fading away gradually on the more refrangible side. The sharp edge did not coincide with the sharp edge of A, the wave length being about 7660. No band corresponding with B was observed but through a thickness of 6 inches of liquid oxygen a faint band appeared which had precisely the same character as A, the wave length of its sharp edge being 6905. Liquid oxygen is distinctly blue, this color, apparently not being due to ozone. Ozone at a low temperature explodes with great violence.—*Phil. Mag.*, V, xxxiv, 205, March, 1893. G. F. B.

5. *On the Production of Hydrogen Peroxide in the Electrolysis of Sulphuric acid.*—KURILOFF has investigated the production of hydrogen peroxide and of persulphuric acid when dilute sulphuric acid of different strengths is electrolyzed. He employed for this purpose an apparatus which permitted the separate collection of the products formed at the two electrodes. The hydrogen peroxide was determined by titration with potassium permanganate and the persulphuric acid by adding a known quantity of ferrous salt to the solution and titrating back with potassium permanganate. The results of his experiments are: (1) The quantity of hydrogen peroxide formed is very small; (2) hydrogen peroxide and persulphuric acid may be simultaneously formed at both electrodes, but the peroxide is not always accompanied by persulphuric acid; (3) the formation of both products is intimately connected with the concentration. Persulphuric acid only appears when the solution contains over 1 per cent of sulphuric acid; hydrogen peroxide when the concentration is over one per cent; (4) mixtures containing 3, 47 and 73 per cent of acid respectively behave differently from other mixtures with regard to the amount of peroxide formed when they are electrolyzed. This is considered by the author to be due to the fact that the composition of these solutions approximates to that required by the hydrates containing $(H_2O)_{150}$, $(H_2O)_6$ and $(H_2O)_2$ to each molecule of H_2SO_4, since according to Mendeléeff all these hydrates exist in solution.—*J. Soc. Chim. Russe*, xxiii, 235; *J. Chem. Soc. London*, lxiv, (ii), 108, March, 1893. G. F. B.

6. *On the Preparation of Pure Phosphoric oxide.*—As usually prepared, phosphoric oxide always contains more or less of the lower oxides mixed with it. SHENSTONE and BECK have proposed to obtain it pure, by passing it in vapor mixed with

oxygen, over platinum sponge. For this purpose a piece of combustion-tube about 90^{cm} long and 2^{cm} in diameter, is divided into two nearly equal chambers by a constriction, a small lateral tube rising from the constricted portion. Immediately beyond this the tube is packed with fragments of platinum sponge; and on the other side of it is placed a large platinum boat containing the phosphoric oxide previously compressed into cylinders. The platinum sponge is heated to redness and a current of oxygen is supplied at the end of the tube and also at the middle by the lateral tube above mentioned. The sublimed product is received in a tube sliding into the combustion-tube near its end, from which it is pushed into a well dried bottle. As thus prepared, the phosphoric oxide no longer reduces a solution of silver-nitrate nor one of mercuric chloride. Nor does its solution on evaporation and ignition give the odor of phosphine. It doubtless contains a little metaphosphoric acid. The authors find that the last traces of the lower oxides are not removed by this roasting in oxygen even for weeks.—*J. Chem. Soc.*, lxiii, 475, April, 1893.

G. F. B.

7. *On the Constitution of Hydroxylamine.*—In view of the fact that hydroxyl compounds of nitrogen give up more or less readily the elements of water to form new nitrogen compounds, Kolotoff has sought by acting on hydroxylamine with ammonia to bring about the reaction $NH_2.OH + NH_3 = N_2H_4 + H_2O$. It was found, however, that this reaction did not take place even when the two substances were heated together at 100° for 24 hours. He therefore concludes that free hydroxylamine contains no hydroxyl and that its formula should be $H_2N:O$. Moreover, it is known that when a salt of hydroxylamine is treated with a solution of bromine in an excess of strong sodium hydroxide only half its nitrogen is evolved in the free state, the other half being probably oxidized to acid, according to the equation:

$$(NH_2O)_2 = NH_3 + HNO + H_2O$$

the ammonia itself being subsequently oxidized. To test this view the author oxidized in the cold a weighed quantity of a hydroxylamine salt, dissolved in a large excess of NaOH, with the theoretical quantity of bromine required by the above equation. After removal of the excess of soda the solution was precipitated with copper sulphate, the precipitate collected, dried and weighed. Its mass was 4·9^{grms} that required by theory being 4·3^{grms}; corresponding to the formula $Cu(NO)_2.H_2O$. It does not lose weight when heated to 136° but blackens when treated with soda. The author considers it to be the dihydrogen cupric salt of an acid $H_4N_2O_3$ which he calls "pyrohyponitrous acid." Hydroxylamine sulphate loses weight at 125°–130°, very rapidly at 136°, the maximum loss being 28·4 per cent. The ratio between the nitrogen and sulphur in the residue seems to suggest formation of salts of both N_2H_4 and N_2H_2.—*J. Soc. Chim. Russe*, xxiii, 3; *J. Chem. Soc. London*, lxiv, (ii), 114, March, 1893.

G. F. B.

8. *Chromophotography.*—M. MAREY, continuing his studies upon the application of instantaneous photography to the investigation of the motion of swimming animals, has devised a special form of apparatus which he believes will prove of great utility in experimental hydrodynamics. A tank is filled with water in which is suspended a number of small bodies consisting of a mixture of wax and rosin which are silvered. The density of the water is then suitably modified by the addition of salt or other substance, in order that the small bodies may be disseminated throughout the liquid. The side of the tank has a backing of black velvet and light is reflected into the water by means of suitably placed mirrors thus illuminating the suspended particles. Interesting reproductions of photographs are given.—*Comptes Rendus*, May 1, 1893, pp. 913–924. J. T.

9. *Reflection of Electrical Waves at the extremity of a linear Conductor.*—Mr. BIRKELAND points out the applicability of Poynting's theories for the explanation of the resonance phenomena discovered by Hertz. The electromagnetic energy in the field surrounding the conductor moves in space in a direction normal to the lines of electric force and magnetic force at each point. By considering this theorem, Birkeland is led to an explanation of multiple resonance, and to the various discrepancies between theory and experiment noticed by those who have studied the Hertz phenomena.—*Comptes Rendus*, April 17, 1893, pp. 803–806. J. T.

10. *Electrical Waves and light waves.*—V. BJERKNES finds that the extinction power of metals for electrical waves increases with good conductors. It also increases with the magnetism of the conductor. The swifter the electrical waves the less distance do they penetrate into the conductor. The author points out various discrepancies between the electromagnetic theory of light, the ordinary theory, and believes that electrical waves represent the motion of molecules as a whole, while the ordinary light waves deal with the motion of individual molecules. He also believes that a study of the action of very quick electrical oscillations on magnetic molecules will fix a limit to the inertia ratio of an iron molecule.—*Ann. der Physik und Chemie*, No. 4, 1893, pp. 592–605. J. T.

11. *New Electrometers.*—BJERKNES has described a new electrometer which he has used in his researches on Hertz phenomena; it consists of a thin plate of aluminum suspended at an angle of 45° between thin plates of an air condenser. When the latter are connected with the poles of a Ruhmkorf coil the aluminum plate tends to set in the line of electrical force between the plates. A simple formula connects the angle of turn of the plate with the difference of potential of the terminals or plates of the air condensers. C. Christiansen suspends two plates separated by mica, by suitable wire, between the plates of an air condenser. When the latter are maintained as a certain difference of potential, the suspended plates tend to turn so as to place themselves at right

angles to the lines of force between the condenser plates. The author gives the simple theory and examples of the working of the new instrument.—*Ann. der Physik und Chemie*, No. 4, 1893, pp. 592–605, pp. 726–733. J. T.

12. *Magnetic Properties of Liquid Oxygen.*—At a discourse delivered before the Royal Institution, Professor Dewar exhibited a pint of liquid oxygen. The temperature of the liquid oxygen at atmospheric pressure was 180° C. Reference was made to a remarkable experimental corroboration of Lord Kelvin and Professor Tait's thermo-electric diagram for low temperatures. If lines of copper and platinum were prolonged in the direction of negative temperature they should intersect at −95° C. Similarly copper and palladium lines would cut one another at −170° C. If the diagram is correct the E. M. F. of the thermo-electric junction of these pairs of metals should reverse at these points. A Cu–Pt junction connected to a reflecting galvanometer was placed in oxygen vapor and cooled down. At −100° C. the spot of light stopped and reversed. A Cu–Pd junction placed in a tube containing liquid oxygen gave a reversal at −170° C. Liquid oxygen is a non-conductor of electricity. A spark taken from an induction coil one millimeter long in the liquid requires a potential equal to a striking distance in air of 25^{mm}. Thus oxygen is a high insulator. The magnetic moment of liquid oxygen is about 1000, when the magnetic moment of iron is taken as 1,000,000. Between the poles of the magnet all the liquefied air went to the poles, there was no separation of the oxygen and nitrogen. Liquid air has the same high insulating power as liquid oxygen. At −200° C. the molecules of oxygen had only one-half of their ordinary velocity, and had lost three-fourths of their energy. Liquid oxygen had no action upon a piece of phosphorus and potassium or sodium dropped into it. A photographic plate placed in liquid oxygen could be acted upon by radiant energy and at a temperature of −200° C. was still sensitive to light. Professor M'Kendrick had tried the effect of low temperatures upon the spores of microbic organisms by submitting in sealed glass tubes blood, milk, flesh, and similiar substances for one hour at a temperature of −182° C. and subsequently to a temperature of blood heat. The tubes on being opened were all putrid. Seeds also withstood a similar amount of cold. These experiments proved the possibility of Lord Kelvin's suggestion that life may have been brought to the newly cooled earth upon a seed-bearing meteorite.—*Nature*, May 25, 1893, pp. 89–91. J. T.

13. *Specific Heat of Liquid Ammonia.*—Dr. Hans von Strombeck has called the attention of the editors to the paper by himself in volume cxxx of *the Journal of the Franklin Institute* (Dec. 1890, p. 467) in which he gives a detailed account of his determination of the specific heat of liquid ammonia. The mean result obtained was 1·22876. This result should properly have been referred to in the paper upon the same subject published in our March number of this year, page 200.

14. *On the value of the meter in English inches;* by C. B. COMSTOCK, U. S. A. (Communicated).—In April 1885 I read a paper before the National Academy of Sciences in which the value of the meter in terms of the yard was given, as derived from comparisons of a meter (R 1876) and Clarke yard A, both formerly belonging to the U. S. Lake Survey. This value was, meter =39·3699 inches.

A note from Dr. Benoit of the International Bureau of Weights and Measures of 27 March 1893, gives the value of the Toise of Bessel in terms of the meter, from Dr. Benoit's comparisons: of Toise No. 10 in terms of the Toise of Bessel from Peter's comparisons and of Toise No. 10 in terms of the yard from Clarke's comparisons: the resulting value of the meter is,

Meter=39·3699 inches.

These equal results obtained through independent routes, indicate that this value has a high degree of accuracy.

Army Building. New York City,
May 17, 1893.

15. *A Student's Manual of a Laboratory Course in Physical Measurements;* by WALLACE CLEMENT SABINE. 126 pp. Boston, 1893. (Ginn & Co.).—This little manual is of special interest as detailing the series of 72 experiments given in the prominent Physics course at Cambridge as also at the Harvard summer school. As given in the college, it requires about 180 hours from the student in the laboratory with the requirement of one half as much time given to outside study.

II. GEOLOGY AND MINERALOGY.

1. *The Tertiary Revolution in the Topography of the Pacific Coast;* abstract of a paper read May 10th, 1893, by J. S. DILLER before the Geological Society of Washington, D. C. A preliminary study of the ancient plains and peneplains of erosion in Northern California and the distribution of the associated sedimentary formations laid down upon their borders, as well as of the large masses of the auriferous gravels deposited upon their gentle slopes, has thrown much light upon the condition of that region during the Eocene and early Neocene. It has afforded a basis for estimating the amount of elevation which the northern end of the Sierra Nevada has experienced since the close of the Miocene. In the Lassen Peak region strata which were laid down during the Miocene in an estuary have since been raised in one place to 3400 and in another to 4000 feet above the sea. The amount of elevation in that district increases southward and at the northern end of the Sierra Nevada the upheaval has been at least 4000 feet and probably over 5000 feet. The Klamath mountains and Coast range have been even more profoundly affected by the same movement.

2. *On Urnatella gracilis;* by C. B. DAVENPORT. Bulletin Mus. Comp. Zoöl., vol. xxiv, No. 1, pp. 1–44, plates 1–6, 1893.—This little known and aberrant Bryozoan has been made the subject of special study by Mr. Davenport. It was first noticed by Leidy in 1851, and later (1870 and 1884) further observations on its anatomy and physiology were made by him. The anatomy and non-sexual reproduction are now more fully described, and the following important conclusions are reached: *Urnatella* is closely related to *Pedicellina.* The Endoprocta are more primitive than the Ectoprocta, as the latter pass through stages resembling the adult condition of the former. The Endoprocta bear only a superficial resemblance to *Phoronis.* The true relationships of the Bryozoa are with the lowest worms, particularly with the Rotifera. The Bryozoa and Rotifera, together with the Mollusca, came from one phylum, and "after the Rotifer stem had branched off, the common Mollusco-Bryozoan stem produced tentacles on the lateral ridges; that the two groups then soon separated, the mollusca to undergo an extensive and complicated development, the Bryozoa to remain at a low level."

C. E. B.

3. *Lehrbuch der geologischen Formations-Kunde, fur Studirende und zum Selbstunterricht,* von Dr. EMANUEL KAYSER, Prof. Univ. Marburg. 386 pp. 8vo, with many figures of sections and fossils. Stuttgart, 1891. (Ferdinand Enke.)—A concise yet detailed account of the successive geological formations and their characteristic fossils.

4. *Mineral Resources of the United States*—Calendar year 1891. DAVID T. DAY. 630 pp. Washington: 1893.—This is the ninth volume of the valuable series upon the Mineral Resources of this country. Like its predecessors it contains a large amount of useful information, compiled so as to be readily accessible. The article upon aluminum is especially full, and we note as of particular interest the statements made in regard to the occurrence of bauxite in this country, in Alabama, Georgia and Arkansas. As quoted from Prof. E. A. Smith, bauxite has been mined in Alabama since November, 1891, and in the year following some 3600 tons were shipped from Piedmont, while from Hermitage, Georgia, about 1300 tons had been mined up to July, 1892. The Alabama ore is stated to carry from fifty to sixty per cent of alumina. It occurs associated with limonite and kaolins in irregular beds, beneath the Knox dolomite of the Lower Silurian. The best known occurrences are near Rock Run Furnace in Cherokee County, and it has also been discovered near Jacksonville in Calhoun County. J. W. Spencer, State Geologist, states that the Georgia bauxite occurs in the residual clay from the decomposition of the Knox dolomite in the belt commencing near Adairsville and extending to the southwest. It occurs in pockets often of great extent and is frequently associated with kaolin, and at one locality with gibbsite. It is mainly in concretionary nodules forming large masses or small kidney-shaped lumps

scattered through the clay. The Arkansas bauxite occurs, as stated by Prof. Branner, in the Tertiary in the neighborhood of eruptive syenite; it is pisolitic in structure, and varies somewhat widely in color and composition. A series of analyses from the different localities is also given (pp. 152–154).

5. *Minéralogie de la France et ses Colonies*, A. LACROIX. Tome premier (1re partie). 304 pp. 8vo. Paris, 1893. (Baudry et Cie.).—This is a work of much value, giving not only the results of earlier observations, but also the many original observations, especially on the physical side, of the indefatigable author. Minute detail in regard to special mineral localities is much needed, but can be given only in a work like this, which is devoted to a limited field.

6. *Sodalite-syenite from Montana.*—In the paper upon this subject by LINDGREN and MELVILLE, in the April number, the table giving the composition of albite and orthoclase near the top of p. 296 is stated incorrectly. It was intended to read as follows:

	Albite.	Orthoclase.
SiO_2	68	66
Al_2O_3	21	19
K_2O		13
Na_2O	11	2

7. *A Summary of Progress in Mineralogy and Petrography in* 1892.—Professor W. S. BAYLEY's excellent notes, published in the monthly numbers of the *American Naturalist*, have been collected in pamphlet form, as in former years, and thus give a very convenient summary of the work done in the sciences named through the year. A topical index is added at the end.

8. *A large Australian Meteorite.*—It is stated that an enormous meteorite, weighing nearly one ton, from western Australia, has been received by Mr. J. R. Gregory, of Charlotte St., Fitzroy square. It is 4 feet 2 inches long by 2 feet 3 inches wide, and 2 feet 6 inches thick.—*Knowledge*, May 1st, 1893.

III. BOTANY.

1. *Plants of Orizaba.*—We have to note the issue of a posthumous work by the late Mr. Seaton, assistant Curator of the Gray Herberium of Harvard University. It comprises descriptions of his collections made during a journey to Mexico by the author. It is published in the Proceedings of the American Academy, Boston. G. L. G.

2. *Die natürlichen Pflanzenfamilien.*—The eighty-fourth installment of this work, to which we have made frequent reference, is the last one at hand. The publisher, Wilhelm Engelmann, of Leipsic, has spared no pains to maintain from the first, a very high standard of typography and illustration. It will be remembered that its earliest editor, EICHLER, died not long after the work was well in hand. It is now our sad duty to announce that

the editoral staff has sustained another loss in the premature death of Professor PRANTL, who passed away on the 24th of February. Professor ENGLER will now have entire charge of the undertaking. Although this additional care must be a heavy burden on Professor ENGLER, it ensures for the volumes even greater unity of design and accomplishment than is possible under a double editorship. G. L. G.

3. *Rainfall and Leaf-form.*—Professor Stahl of Jena has published some interesting studies which he carried on at the mountain station of the Botanic Garden at Buitenzorg, Java. The mountain station is at Tjibodas, about 4,500 feet above sea-level, on a part of the volcanic Gedeh. No one who has seen the suddenness with which the rain which falls in the tropics is disposed of by the luxuriant foliage of a hillside can fail to be interested in Stahl's investigation. Some of the adaptations are among the most interesting in the whole range of vegetable forms, especially those which were connected with the rapid drying of the leaf itself in a comparatively moist atmosphere.

Professor Stahl has also busied himself with an examination of some of the means by which tropical plants protect themselves against the very heavy blows from rain-drops in the tropics. A good review of the paper, which appears in the Annals of the Buitenzorg Garden, is given in the 10th number (May 16) of *Botanische Zeitung.* G. L. G.

4. *Turgescence and transpiration in fleshy plants;* by ÉPHREM AUBERT, (Ann. Sc. Nat., vii Ser., T. 16).—The researches of this experimenter have brought out in a very clear manner certain relations which exist between the occurrence of vegetable acids in some fleshy plants and their slow transpiration. The fact that fleshy plants possess, especially in the dark, a notable amount of some organic acid, has been long known. To this acid, as it occurs in *Crassulaceæ*, Mayer gave the name of *isomalic.* In this Natural Order, it is associated with *tartaric* acid and tannin. In *Ficoideæ*, the acid is oxalic, while in Cactaceæ there is *oxalic* acid together with gums which later differ in their behavior to water, some being soluble, and others merely swelling in water.

The author concludes that the curve of water transpired by different parts of a fleshy plant has its minimum corresponding to the maximum content of organic acids and gums. Of course this resolves itself into the physical relations which depend on the effect of dissolved substances to retard evaporation.

G. L. G.

5. *On the origin of Endogens from Exogens.*—Rev. GEORGE HENSLOW, whose interesting work on the *Origin of Floral Structures* is well known to our readers, has a suggestive paper in the May (15th), number of the Journ. of the Linnean Society, on the vexed question of the relation in point of time between dicotyledonous and monocotyledonous orders. The subject is discussed from histological and morphological points of view and the following conclusions are reached.

That endogens and exogens have had some common origin is, in the first place, obvious from the numerous points of agreement between their organs and tissues generally, as shown, e. g., in the structure of their flowers and anatomy of their roots, etc.; but the object of the present paper was to prove if possible, that there was a more special connection between endogens and an aquatic habit.

The coincidences in points of structure between endogens generally and the aquatic, and subaquatic exogens, as well as such exogens as may reasonably be supposed to have had an aquatic ancestry, are perhaps more numerous than the points of agreement with exogens generally. Nature supplies us with several "experimental verifications" in the alterations of structure in amphibious plants according as they live in water or on the land. These coincidences may be thought sufficient to prove that endogens have in the first place descended from very early types of exogens which preceded them; and that, secondly, the more immediate cause of their origin was an aquatic habit of life assumed by certain primitive exogenous plants.

To state the process of adaptation in as few words as possible, one might say that it was effected by means of the joint action of the external influences or forces of the environment and the internal responsive power of living protoplasm, so that when a terrestrial and aërial plant is grown in water, or a water-plant is transferred to land, the direct action of the new environment compels the plant (provided it can survive the change), to alter its structure so that the plant becomes at once adapted to the new medium. The change from land to water brings on therefore what may be called adaptive degenerations in every part of the plant. Conversely, a transference from water to land induces a tendency to restore the lost features, resulting, it may be, in a greatly enhanced and vigorous growth.

Whether there were several or few aquatic ancestors, or only one, the author does not venture to suggest, although he hints at the likelihood of there having been many. The difficulty in dealing with this question lies in the fact that at present it is impossible to trace affinities between the flowers of existing endogens and those of any existing orders of exogens. The conclusions of this important paper have been given above substantially in the words of the author, only a few unimportant changes having been made.

G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *The American Association for the Advancement of Science.*—The next meeting of the American Association for the Advancement of Science will be held at Madison, Wisconsin, from August 16th to 23rd. The President is Professor William Harkness.

This meeting is to be preceded by the meeting of the *Geological Society of America*, which is to be held at Madison on the 15th and 16th. It is to be followed by the *World's Geological Congress* to be held at Chicago during the fourth week of August, beginning on the 24th. Prof. T. C. Chamberlin of the University of Chicago is Chairman of the Committee.

2. *Australasian Association for the Advancement of Science.*—The next meeting of the Australasian Association for the Advancement of Science will be held in Adelaide, South Australia, commencing on September 25th, 1893. It will be presided over by RALPH TATE, F.L.S., F.G.S., Professor of Natural Science at the University of Adelaide. The following remarks are quoted from the circular issued, which gives the details in regard to the meeting :—

At the time fixed for the meeting, South Australia will be at its best. There is no better time at which to visit Australia than when spring is merging into summer. To naturalists, this time of year is specially attractive, and these are reminded that at the meeting of the Association they will come into contact with men of like tastes from all parts of Australia. Should visitors wish to prolong their trip, they are advised to visit during the months of October and November the principal objects of interest in the mainland, and in December, January, and February to pass on to New Zealand and Tasmania.

The general Hon. Secretaries who will give all needed information are: Professor A. Liversidge, of Sydney, and Professors E. H. Rennie and W. H. Bragg, of Adelaide.

3. *British Association.*—The next meeting of the British Association will be held at Nottingham, beginning September 13th. The President is Dr. J. S. Burdon-Sanderson.

4. *Owen Memorial.*—At a meeting of the Royal Society held January 21st, 1893, it was resolved, that "it is desirable that the eminent services of the late Sir Richard Owen in the advancement of the knowledge of the sciences of Anatomy, Zoology and Paleontology should be commemorated by some suitable memorial." This memorial is to consist primarily of a marble statue to be placed in the hall of the Natural History Museum in London. The Trustees of the British Museum have expressed their willingness to receive the statue, and donations to this end are now called for; they may be sent to the treasurer, Sir William H. Flower, Natural History Museum, London, S. W. It is stated that the sum already contributed amounts to nearly six hundred pounds.

5. *Die Fortentwicklung der elektrischen Eisenbahn-Einrichtungen*, von L. KOHLFÜRST. 296 pp. 12mo. Vienna, Pest, Leipzig, 1891. (A. Hartleben's Verlag).—This little volume belongs to the electro-technical library of A. Hartleben, which has been repeatedly noticed in these pages. It gives an account of the present state of the application of electricity to the railroad, including the use of signals of many kinds, of the telephone, and many allied subjects.

6. *Gravity Research: Determinations of Gravity with half-second Pendulums on the Pacific Coast, in Alaska and at Washington, D. C., and Hoboken, N. J.;* by T. C. MENDENHALL. 57 pp. Washington, 1892, (U. S. Coast and Geodetic Survey), Appendix no. 15. Report for 1891.—Professor Mendenhall discusses here the new half-second pendulum and describes the use at several stations, showing the high degree of accuracy obtainable with it. It is also shown that the free pendulum has a very important use as a time standard.

7. *The Colors of Cloudy Condensation,* by Prof. CARL BARUS. pp. 488–521. Reprinted from the American Meteorological Journal, March, 1893.—This interesting article is a full discussion of a subject which the author presented briefly in the February number of this Journal (page 150.)

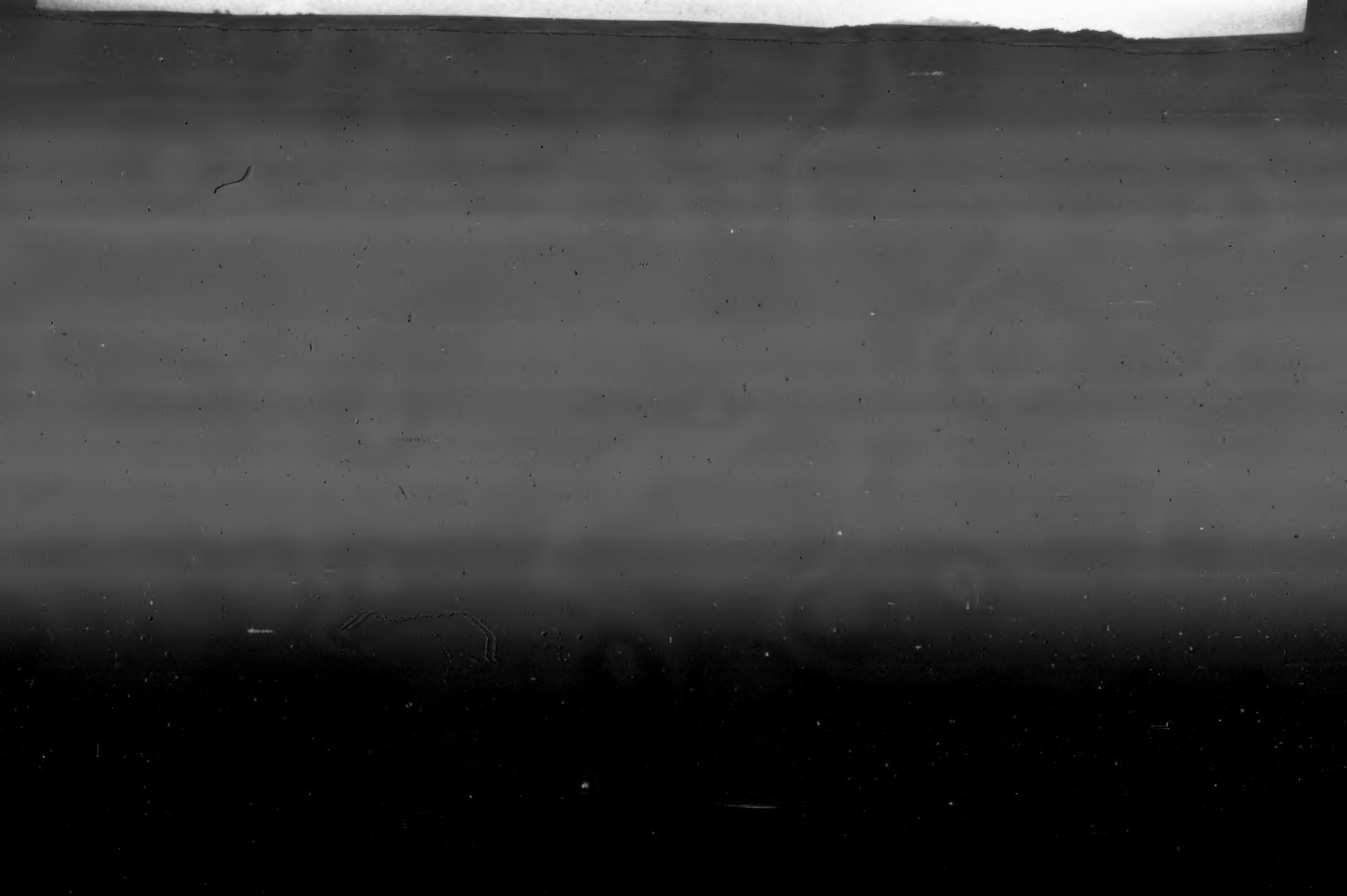
8. *Outlines of Forestry;* or the elementary principles underlying the Science of Forestry. Being a series of Primers of Forestry; by EDWIN J. HOUSTON. 254 pp., Philadelphia, 1893. (J. B. Lippincott Co.).—There is certainly a most urgent call for enlightenment throughout this country in regard to the preservation and wise use of our forests, and a little book like the one in hand, which presents the whole subject in so popular a form as to appeal to all readers, should not fail to accomplish much good.

9. *Naples Zoölogical Station.*—Attention is called to the announcement in the advertising sheet, by Prof. Agassiz, that applications will be received from candidates who desire to occupy the table at the Naples Zoölogieal station, placed at the disposal of the faculty of the Museum of Comparative Zoölogy at Cambridge from October, 1893.

10. *Krantz's Catalogue of Rocks.*—Dr. Krantz of Bonn has recently issued an extended catalogue containing: first a systematic list of rocks arranged by Dr. W. Bonhus and Dr. Pohlig with literature references; also lists of special collections arranged according to particular subjects, and finally a catalogue of thin sections of authentic specimens in large numbers.

11. *A Manual of Machine Drawing and Design,* by DAVID ALLAN LOW and ALFRED WILLIAM BEVIS. 367 pp. 1893, London and New York, (Longmans, Green & Co.).—Students in mechanical engineering will find this Manual of great assistance. The various parts of machines of many kinds are described here with great fullness of illustration and exactness of statement, from the simplest form to the triple-expansion engine. Whether the subject is screws, bolts and nuts or the most complex boilers, the treatment is throughout admirably thorough and practical.

12. *The Hawks and Owls of the United States* in their Relation to Agriculture. Prepared under the direction of Dr. C. Hart Merriam, Ornithologist, by A. K. FISHER, M.D. 210 pp. Washington, 1893, (Government Printing Office.)—A handsomely illustrated work giving descriptions of the various hawks and owls known in the United States. Particular attention is given to the examination of the stomachs of many of the birds as showing the part they play in destroying insects, rodents, etc.



Big Discounts on Minerals till July 1st.

Special Offer.—In order to secure funds with which to meet heavy obligations maturing July 1st, we make a most extraordinary offer. On all purchases for which we are paid "Spot cash" prior to July 1st, we will allow discounts as follows:

20	per cent. on purchases netting less than			$10.00	
25	per cent.	"	"	$10.00 to	$50.00
33⅓	per cent.	"	"	$50.00 to	$100.00
40	per cent.	"	"	$100.00 to	$1,000.00
45	per cent.	"	"	over $1,000.00	

Special arrangements will also be made with customers desiring to profit by the above offer, but who have not the ready cash. This offer will positively be withdrawn July 1st and will never again be made. It applies to all minerals in our stock both in New York and Chicago stores, viz. specimens, collections, blowpipe minerals, microscopic mounts and gems, except that we cannot take time to select anything of lower price than 25 cents. Should the rush of orders be so great as to prevent our filling them all during June, we reserve the right to send the material as soon as possible after, but *we must in every instance be paid cash in full prior to July 1st.* We also reserve the right to withdraw this offer at any time.

SOME THINGS FROM WHICH TO CHOOSE.

Sulphur Crystals and Groups, 50 cts. to $7.50.
Rubellite in Lepidolite, California, 25 cts. to $50.00.
Amazon Stone, cleavages, Va., exceedingly fine, 25 cts. to $2.50.
Calcite from Egremont, Bigrigg or Stank Mine, Mexico, Bad Lands, Bisbee, 25 cts. to $10.00.
Fluorite, green, blue, pink, yellow, white, purple, 25 cts. to $10.00.
Barite, England, fine groups and crystals, 25 cts. to $3.50.
Hematite and Quartz, England, very beautiful, 25 cts. to $2.00.
Sphalerite, England, Mo., or Binnenthal, 50 cts. to $10.00.
Apophyllite, Mexico, 25 cts. to $12.50.
Amethyst, Mexico, 25 cts. to $3.50.
Proustite, Pyrargyrite, Stephanite, Polybasite, Argentite, $1.00 to $12.50.
Prasopal, the beautiful green opal, 50 cts. to $2.50.
Precious Opal, Australian and Mexican, full of fire, 25 cts. to $10.00.
Hyalite, Mexico, very choice, 25 cts. to $2.50.
Opal Agate, Mexico, beautiful, 25 cts. to $2.50.
Cassiterite, Wood-Tin, Mexico, 25 cts. to $1.50.
Topaz xls., Mexico, Japan, Urals, 25 cts. to $12.50.
Laumontite, Nagyag, extra large, fine crystals, $1.00 to $10.00.
Hauerite xls, 25 cts. to $10.00; Gold, Silver, Copper, Lead.
Hiddenite xls, 25 cts. to $10.00; Rutile xls, N. C., 25 cts. to 50 cts. Auerlite, $1.00.
Epidote xls, Tyrol, very fine, 50 cts. to $5.00.
Pink Grossularite xls, loose and in matrix, 25 cts. to $2.50.
Descloizite, bright scarlet, 25 cts. to $2.50.
Chalcotrichite, Arizona, extra fine, 25 cts. to $5.00.
Malachite and Azurite, 25 cts. to $5.00.
Stibnite, Japan, 25 cts. to $10.00.
Labradorite, Sunstone, Jasperized Wood, Agates, Crocidolite.
Herkimer Quartz xls, Ark. Quartz, Pyrite twins and groups.
Smithsonite, Adamite, Laurionite, Phosgenite.
Gem Tourmaline xls; Gem Beryls; Gem Sapphires, Rubies; Zircons.
Eudidymite xls.; Orangite; Cobaltite; Manganite; Bismuth.
Argyrodite, Roselite; Ullmannite, Arsenic, Antimony.
Rowlandite, Thorogummite, Fergusonite, Cyrtolite, Allanite.
Tysonite, Bastnasite, Phenacite, Bertrandite.
Anatase, Adularia, Acanthite, Domeykite, Stromeyerite.
Brookite, Eudialyte, Monticellite, Aegirite.
Aguilarite; Livingstonite; Orpiment; Realgar.
Pollucite; Beryllonite; Matlockite; Altaite; Lehrbachite.
Diamond xls, Senarmontite; Sylvanite; Nagyagite; Tiemannite.
Essonite, Ouvarovite, Spessatite and Salida Garnets.
Prehnite, Hexagonite, Millerite, Mountain Cork, Stalactites.
Rhodonite, Troostite, Willemite, Zincite, Franklinite.

GEMS.

Rubies, $10.00; Sapphires, $2.00 to $5.00; Opals, 50cts. to $10.00; Tourmalines, 50 cts. to $5.00; Chrysoberyls, $1.00 to $25.00; Garnets, 50 cts. to $5.00; Amethysts, 50 cts. $10.00; Aquamarines, $1.00 to $5.00; Topaz, 50 cts. to $20.00; Moonstones, 25 cts. to $5.00; Oligoclase, Diopside, Beryllonite, etc.

GEO. L. ENGLISH & CO., Mineralogists,

64 EAST 12TH ST., NEW YORK.

World's Fair Branch Store:—

Souvenir Bazaar, 6408 Stony Island Avenue, Chicago.

CONTENTS.

Page.

ART. I.—Studies of the phenomena of Simultaneous Contrast-Color; and on a Photometer for measuring the intensities of Lights of different Colors; by A. M. MAYER 1

II.—Kehoeite, a new Phosphate from Galena, Lawrence Co., S. D.; by W. P. HEADDEN 22

III.—Ammonium-Lead Halides; by H. L. WELLS and W. R. JOHNSTON 25

IV.—Rubidium-Lead Halides, and a Summary of the Double Halides of Lead; by H. L. WELLS 34

V.—The Galveston Deep Well; by E. T. DUMBLE and G. D. HARRIS 38

VI.—Iodometric Determination of the Nitrates; by H. GRUENER 42

VII.—Piedmontite and Scheelite from the Ancient Rhyolite of South Mountain, Pennsylvania; by G. H. WILLIAMS 50

VIII.—Cambrian and the Ozark Series; by G. C. BROADHEAD 57

IX.—One-Volt Standard Cell; by H. S. CARHART 60

X.—Cross Roads Meteorite; by E. E. HOWELL 67

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics—Study of Chemical Reactions by means of the Refractive Index, FÉRY: Preparation of Chlorine by means of Nitric Acid and Manganese dioxide, LUNGE and PRET, 68.—Complex Acids containing Septivalent Iodine, BLOMSTRAND: Refractive Indices of liquid Oxygen, Nitrogen Monoxide and Ethylene, and on the Spectrum of liquid Oxygen, LIVEING und DEWAR, 69.—Production of Hydrogen Peroxide in the Electrolysis of Sulphuric acid, KURILOFF: Preparation of Pure Phosphoric oxide, SHENSTONE and BECK, 70.—Constitution of Hydroxylamine, KOLOTOFF, 71.—Chromophotograph, M. MAREY: Reflection of Electrical Waves at the extremity of a linear Conductor, BIRKELAND: Electrical waves and light waves, V. BJERKNES: New Electrometers, BJERKNES, 72.—Magnetic Properties of liquid Oxygen: Specific Heat of Liquid Ammonia, 73.—Value of the meter in English inches, C. B. COMSTOCK: Laboratory Course in Physical Measurements, W. C. SABINE, 74.

Geology and Mineralogy—Tertiary Revolution in the Topography of the Pacific Coast, J. S. DILLER, 74.—Urnatella gracilis, C. B. DAVENPORT: Lehrbuch der geologischen Formations-Kunde, KAYSER: Mineral Resources of the U. S., 75.—Minéralogie de la France, A. LACROIX: Sodalite-syenite from Montana, LINDGREN and MELVILLE: Summary of Progress in Mineralogy and Petrography in 1892, W. S. BAYLEY: Australian Meteorite, 76.

Botany—Plants of Orizaba: Die natürlichen Pflanzenfamilien, 76.—Rainfall and Leaf-form: Turgescence and transpiration in fleshy plants, E. AUBERT: Origin of Endogens from Exogens, G. HENSLOW, 77.

Miscellaneous Scientific Intelligence—American Association for the Advancement of Science, 78.—Australasian Association for the Advancement of Science: British Association: Owen Memorial: Die Fortentwicklung der electrischen Eisenbahn-Einrichtungen, L. KOHLFÜRST, 79.—Gravity Research, Determinations of Gravity with half-second Pendulums, T. C. MENDENHALL: Colors of Cloudy Condensation, C. BARUS: Outlines of Forestry, HOUSTON: Naples Zoölogical Station: Krantz's Catalogue of Rocks: Manual of Machine Drawing, LOW and BEVIS: Hawks and Owls of the U. S., FISHER, 80.